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The Journal of the American Welding Society

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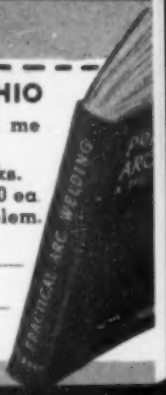

The Journal of the American Welding Society

Published for the Advancement of the Science and Art of Welding

W. SPRARAGEN, Editor

FEBRUARY 1943

VOLUME 22 NUMBER 2

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Welding by the "Shotweld" System Three Thicknesses of 0.109 Inch Stainless Steel for Naval Vessels. *Courtesy E. G. Budd Mfg. Co.*

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The Journal of
The American Welding Society
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Some Observations on Ship Welding*

By David Arnott†

THE purpose of this paper is to present a general picture of ship welding in this country with special reference to what is being done on the emergency ships of the Liberty type of which so many are being built in the various shipyards. A few observations relating to the general subject of fusion arc welding as applied to merchant ship construction are also submitted in the hope that these will serve the useful purpose of promoting an interchange of opinion among the interested members of this Society.

Historical

Twenty-five years ago, during the last World War, the Emergency Fleet Corporation appointed a committee to consider the feasibility of constructing welded ships in view of the then general opinion that the chief obstacle to rapid steel ship construction was the lack of trained riveters. The committee was composed of representatives from interested government departments, classification societies and welding equipment manufacturers under the chairmanship of Dr. Comfort A. Adams, then Professor of Electrical Engineering at Harvard University.

As a result of the committee's deliberations, plans were prepared for a full-size experimental mid-section sub-assembly at the Federal shipyard. This work was well under way and ready for welding at the time of the Armistice. About two weeks before the Armistice, authorization was given for the construction of an all-welded ship of 10,000 tons. Both of these projects were cancelled after the Armistice. This was distinctly unfortunate as the experience which would have been gained in the construction of a large all-welded ocean-going ship along the lines proposed, especially if combined with a satisfactory service record, would have undoubtedly accelerated the application of arc welding to ships and indeed to all other large plate structures.

The deliberations of this committee had one important result in that some of its prominent members led by Dr. Adams, realizing the need for a technical society devoted exclusively to the study of welding problems, took steps which led to the formation in 1919 of the AMERICAN WELDING SOCIETY, which has since done so much to promote and advance the science and art of welding in American industry.

The committee came to the now obvious conclusion that optimum results in the mass production of welded ships could not be achieved in established shipyards laid out for riveted construction by orthodox methods. The members of the committee fully realized the weight-saving possibilities inherent in welded construction, advocated the fullest possible use of unit prefabrication and suggested that much of the welding could very well be done by women. There was considerable difference of opinion with regard to the relative merits of bare wire *vs.* covered electrodes, a controversy which has now been definitely settled once and for all in favor of the latter.

The scheme of putting the ships together was distinctly novel in that it was proposed to erect ships 401 ft. long, 54 ft. beam and 32 ft. 10 in. depth in transverse sections 6 ft. long and to finish one unit completely in an 8-hr. day with the aid of a "header," a combined traveling crane and workshop which was to be moved forward 6 ft. each day. This header was described as a self-contained unit mounting two electrically driven 46-ft. cranes on top and divided into six platform decks carrying the necessary equipment for welders, pipefitters, carpenters and, in fact, everything necessary for the completion of each 6-ft. section.

Figure 1 gives a clear picture of the comparatively small sub-assemblies involved, comprising a double-bottom section plated transversely, a side section plated vertically and deck sections plated transversely, each 6 ft. or two frame spaces in length. The keel, including center girder and rider plate, the bilge section and the sheer strake and deck stringer plates were plated longitudinally in 30-ft. lengths with the idea of reducing the number of joints in these important structural members to a minimum.

The design was stated to be aimed at producing a structure involving (1) a maximum amount of work in the welding shop, (2) the minimum number of crane lifts at the assembly yards and (3) a minimum amount of welding in the field, all of which remain vital considerations today. The paper by Mr. H. Jasper Cox on "The Application of Electric Welding to Ship Construction," which appeared in the 1918 *Transactions* of this Society, refers to the work of this particular committee in more detail and embodies plates showing the proposed shipyard with the header cranes, together with the midship section, which is now repeated in Fig. 1 for ready reference and for comparison with the sub-assembly methods later described for the Liberty ships.

Development

The early development of ship welding in United States shipyards was outlined in a paper read by the author before this Society in 1934 in which the impetus given to welding by the owners and builders of oil tank barges was properly emphasized and particulars given of a large number of welded barges of various sizes and types of construction. It is interesting to recall that the largest all-welded vessel built up to that particular time was the *Poughkeepsie Socony*, 252 ft. by 40 ft. by 14 ft., of 1235 gross tons. I may say that these comparatively small miscellaneous all-welded craft have given every satisfac-

* Presented at the Annual Meeting, The Society of Naval Architects and Marine Engineers, New York, November 12 and 13, 1942.
† Vice-President and Chief Surveyor, American Bureau of Shipping, New York.

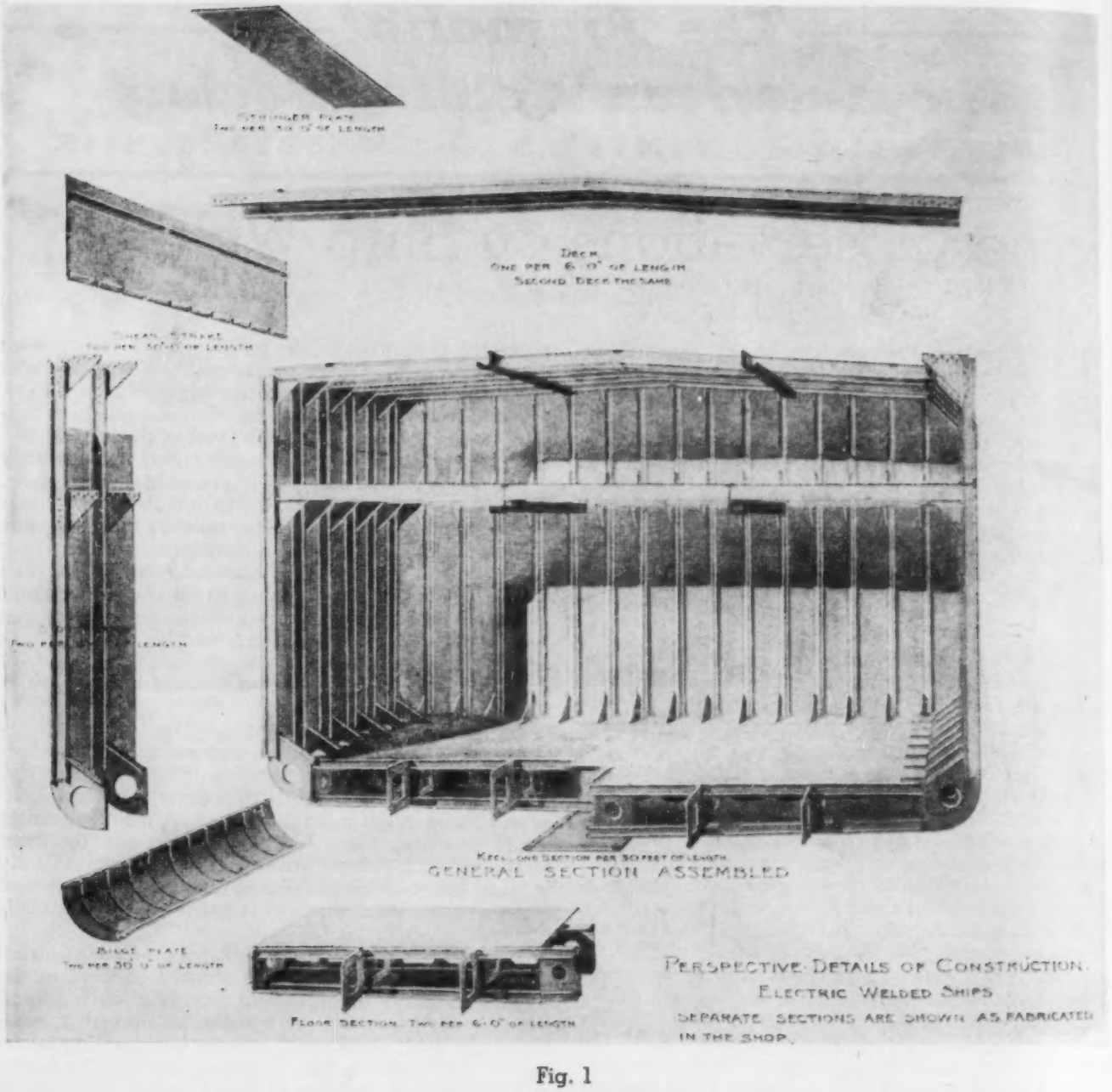
STRINGER PLATE
DECK
ONE PER 6'-0" OF LENGTH
SECOND DECK THE SAME
KEEL - ONE SECTION PER 30 FEET OF LENGTH
GENERAL SECTION ASSEMBLED
BILGE PLATE
FLOOR SECTION - TWO PER 6'-0" OF LENGTH
PERSPECTIVE DETAILS OF CONSTRUCTION
ELECTRIC WELDED SHIPS
SEPARATE SECTIONS ARE SHOWN AS FABRICATED IN THE SHOP.

Fig. 1

tion in service and have fully justified the hopes of their designers and builders. In any event riveted construction for this class of vessel appears to be definitely out for good, as practically all floating equipment under 300 ft. long built in this country in recent years has been completely welded.

Mr. Wolfe's paper read at the last spring meeting gives an admirable picture of a shipyard laid out and organized along modern lines for the mass production of such vessels. In normal times, competition in the building of river craft is extremely keen and that the Dravo Corporation should have gone all-out for welded construction when it did was extremely significant.

It was the experience gained in the construction and operation of small all-welded tankers such as the *White Flash* that gave her builders, the Sun Shipbuilding Company, and her owners, The Atlantic Refining Company, confidence to go ahead with the large ocean-going tanker *J. W. Van Dyke*, 521 ft. by 70 ft. by 40 ft., of 11,650 gross tons. The building of this vessel constituted a landmark in the history of ship welding in this country not only because of the increased size of ship to which welding was applied but also because of the fact that it represented the first use on a large scale of automatic welding in shipyard work.

The construction of this particular vessel was fully described in the paper presented to this Society in 1937 by Messrs. Hudson and Jackson. Since that date the Sun Shipbuilding Company has constructed many large all-welded tankers and that only a few minor changes have been found desirable in erection and welding methods in the intervening years is a tribute to the careful planning exercised in the design and building of the *Van Dyke*. The elaborate stationary equipment designed for sub-assembly welding by the Unionmelt process, and which is peculiar to this particular yard, has been continued although in simplified and improved form in the later installations for the new Sun shipyards.

It should be mentioned that while the *Van Dyke* was riveted at the extreme ends clear of the cargo tank spaces later tankers have been all-welded. The structural arrangements in succeeding vessels are somewhat different

in that the heavy wrapper shell plate associated with longitudinals cut short of the transverse bulkheads as in the bracketless system have been eliminated by providing that desirable measure of continuity of the longitudinals at the bulkhead which is afforded by the fitting of bulkhead brackets continuous through and welded to the longitudinals and bulkhead plating. In the large tankers now building for the Maritime Commission to plans supplied by the Sun Shipbuilding Company the bulkheads are of fluted or corrugated plate construction, a type which readily lends itself to welding and results in a decided saving in weight as compared with the conventional type of bulkhead made up of flat plates and stiffeners.

The advent of the Maritime Commission building program gave a decided boost to ship welding, the Commission having very properly decided to allow the various builders to rivet or weld as they saw fit. The established shipyards originally laid out for riveted construction, by a process of continuous experimentation and increasing application of welding throughout the years, had available a nucleus of experienced and trained personnel which provided the ground work for the production of all-welded ships. Faced with the necessity of constructing new shipyards to take care of a greatly amplified program the question of welding *vs.* riveting as the ideal method of building ships inevitably arose and could no longer be ignored. The Ingalls Shipbuilding Corporation, which received a contract from the Maritime Commission in 1939 to build C3 type ships, decided the question so far as they were concerned by laying out their new yard at Pascagoula for all-welded construction, the first shipyard primarily designed and laid out for the production of large all-welded ocean-going ships.

Our regular shipyards, which in normal peacetimes are prepared to turn out any type of ship between a barge and a battleship, had reached a high degree of efficiency in riveted construction prior to the general adoption of welding. Efficient methods of routing and handling materials and the carrying out of a maximum amount of fabrication on the ground rather than on the ways for such items as bulkheads, fantails, deckhouses, etc., was already common practice in the interests of rapid and economical construction. This is worthy of mention because a layman is apt to get the impression now-a-days that our previous shipyard methods were almost archaic and that the improvements which have taken place in the last year or two were entirely due to an influx of new ideas from dynamic personalities. As a matter of fact, the only revolutionary changes of any permanent value that have occurred are the direct result of the substitution of welding for riveting and the use of the flame torch for plate-edge preparation, cutting manholes, etc., in lieu of shears, planing machines and manhole punches in the use of which the work had to be brought to the machine. Certain practices are in vogue which undoubtedly facilitate the mass production of sister ships at a time when speedy delivery is the primary consideration but these are not likely and probably not expected to survive in ordinary conditions under the stress of commercial competition.

Production records do not just happen but are the result of careful and even meticulous planning, not the least of which is concerned with the training for a specific job of new workers, most of whom never saw a shipyard until they were hired. The educational effort involved is tremendous and reflects great credit on the instructors, most of whom were recruited from our established shipyards. Some of the handbooks on such subjects as "Shipfitting" prepared for use in trade schools are excellent both in conception and material. Under present-day conditions the time and effort spent in the preparation of detail working drawings are considerable, especially where

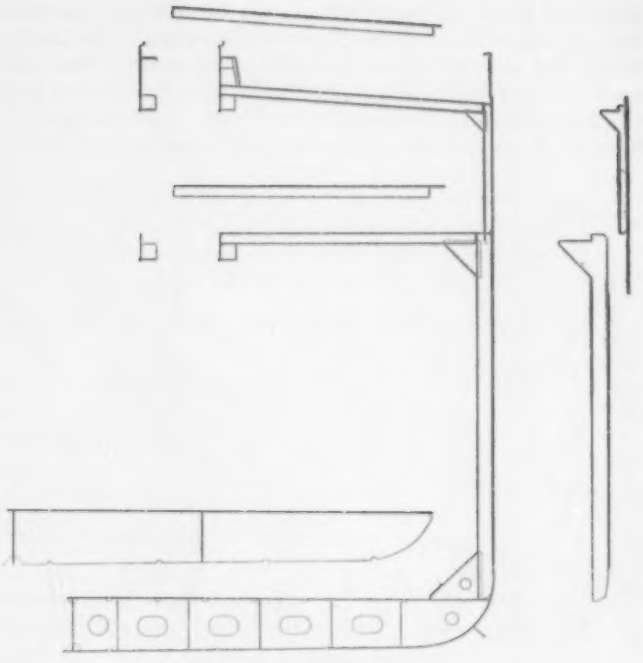

Fig. 2—Midship Section

these are augmented by the use of small-scale models and isometric sketches which are more readily comprehended by the novice. The practice at one of the Kaiser yards building large tankers is to supplement the ordinary working drawings by the issue to the yard of booklets illustrating literally hundreds of different portions of the ship. Each booklet contains an isometric drawing of a specific part together with the material order and welding details, and serves the useful purpose of providing information and guidance for the workmen who are responsible for the fabrication of one particular unit. While the cost of all this preparatory work is appreciable, it is not unduly high if reduced to a per ship basis.

Liberty Ships

The Liberty ship, as it is popularly called, is a flush deck cargo ship 418 ft. by 57 ft. by 30 ft. 4 in. designed to operate at a summer draft of 27 ft. 8 in. with a deadweight capacity of about 10,700 tons. The vessel is transversely framed and has two decks, seven watertight bulkheads and five cargo hatches. The propelling machinery consists of a steam reciprocating engine with two oil-fired watertube boilers. The contract plans were prepared by the Maritime Commission and the working drawings by Messrs. Gibbs & Cox, Inc., as agents for the Commission, with a minimum number of changes from existing drawings gotten out by the same naval architects for the 60 British *North Sand* type ships of similar dimensions, which had already been contracted for in two new United States shipyards. The extreme emergency conditions made it desirable to make the fullest use of available plans and material orders so that material could be rolled and allocated to the various yards with the least possible delay. The British vessels, which are now in operation, are, however, of the closed shelter deck type designed for somewhat less draft and their propelling machinery is different in that steam is supplied by coal-fired Scotch boilers.

In keeping with modern shipbuilding practice in this country the structural arrangements of the Liberty ship were designed with a view to the use of welding for all

principal parts except for the side framing to the shell plating, which it was proposed to rivet with the underlying idea that erection would be facilitated by the presence of rivet holes which could be used to service bolt the side plates in position for welding. The sub-assemblies as shown on the contract plans contemplated fabricating the double bottom in sections half the breadth of the vessel with the vertical keel included in the starboard side units, the longitudinal joint between units being located at the port side of the tank top center strake. The deck panels were laid out to provide a full-width unit forward and aft of each hatch, with one hatch end beam and

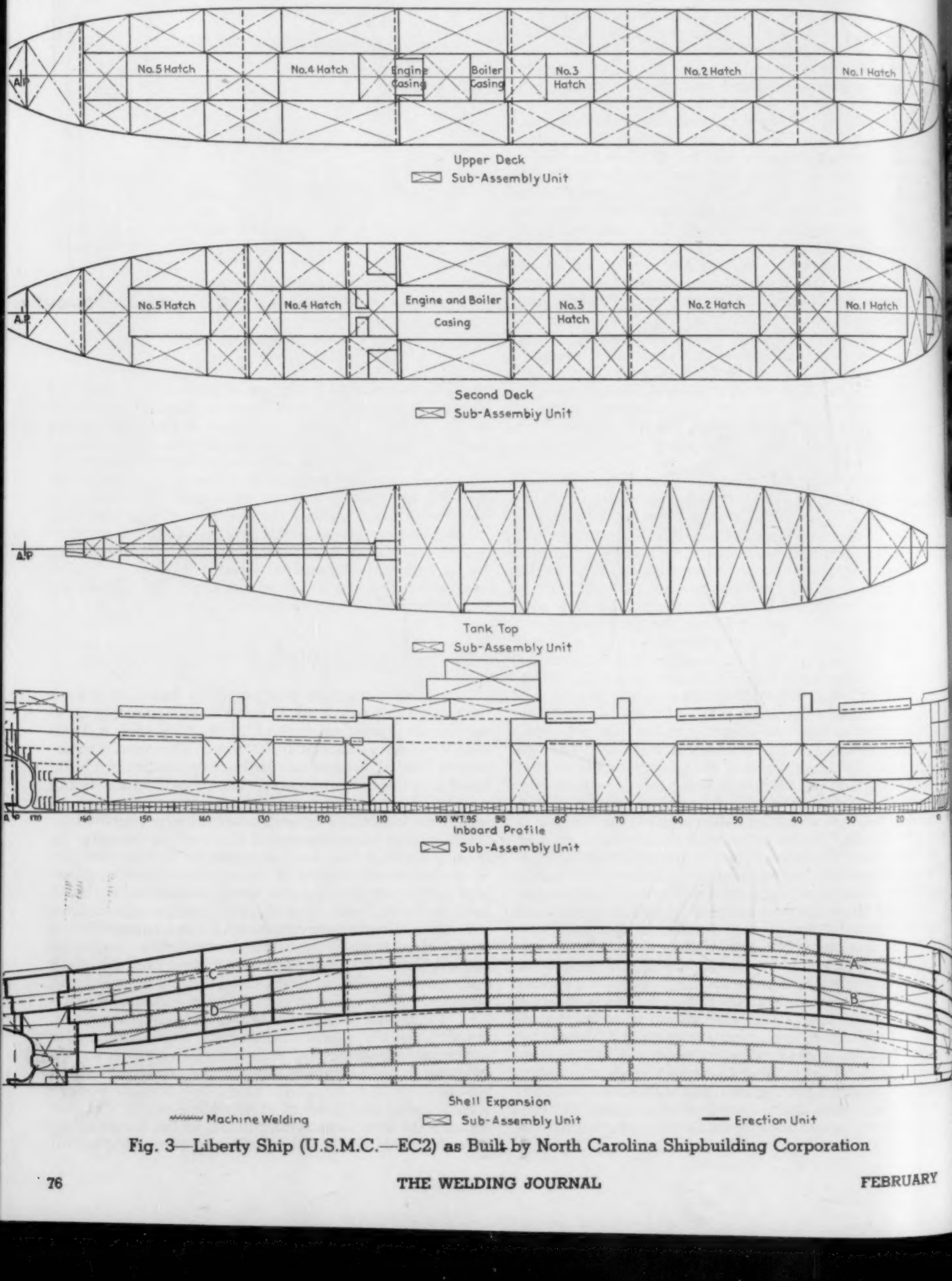

Fig. 3—Liberty Ship (U.S.M.C.—EC2) as Built by North Carolina Shipbuilding Corporation

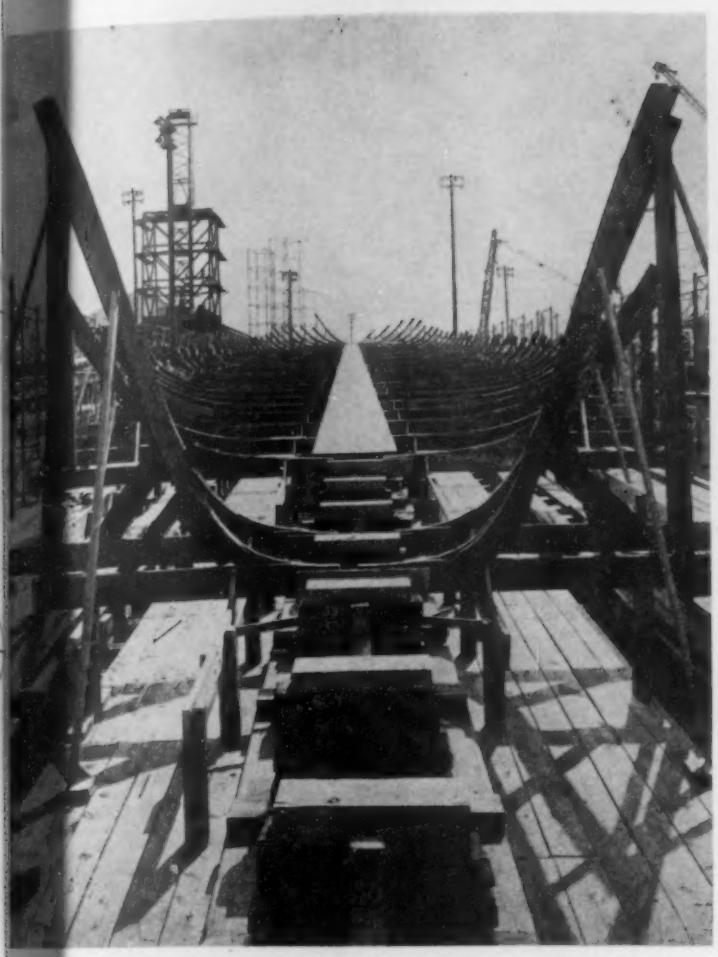

Fig. 4—Looking Forward at Spauls or Cradle with Flat Keel in Place

the deck girders in place, and one unit on each side abreast each hatch with the hatch side girder attached. The shell plating plan showed an orthodox shift of butts with a view to erection by individual plates.

A few of the yards have adhered to the sub-assemblies and welding procedure as originally laid out but most of them have from time to time introduced changes with a view to speeding up production. Different methods of erection have been developed owing to differences in available crane capacity, shop equipment, electric power and skilled labor. The methods and details of welding also differ especially as regards the use and extent of automatic welding. Rigid adherence to so-called "Codes" at this stage of progress of ship welding would handicap sound development and be quite undesirable and in this connection it should be said that the American Bureau has not attempted to dictate welding procedures or to reject proposed methods submitted for approval except where our experience has shown that they are not likely to achieve satisfactory results.

The contract plans showed open floors in the double bottom in association with solid floors every fourth frame except under the engines and at the forward end, and the majority of the yards commenced building in accordance with this arrangement. One yard, however, which had ordered material from their own working plans, fitted solid floors on every frame from the beginning and later eliminated the flat bar floor stiffeners in association with an increase in the thickness of floor plates. The reduction in the number of pieces and in the amount of welding involved undoubtedly simplifies the construction of the double bottom and several yards have since adopted this same arrangement in their later vessels.

Since there are no fewer than 17 new yards with contracts for Liberty ships, it is impossible within the limits of this paper to describe in detail the practices of each individual yard. However, the present method of erection

Fig. 5—Looking Aft at the Bottom Shell Plating Laid on Spauls, Being Dogged Together for Manual Welding of Underside of Butts and Seams After Which the Dogs Are Removed to Facilitate Machine Welding

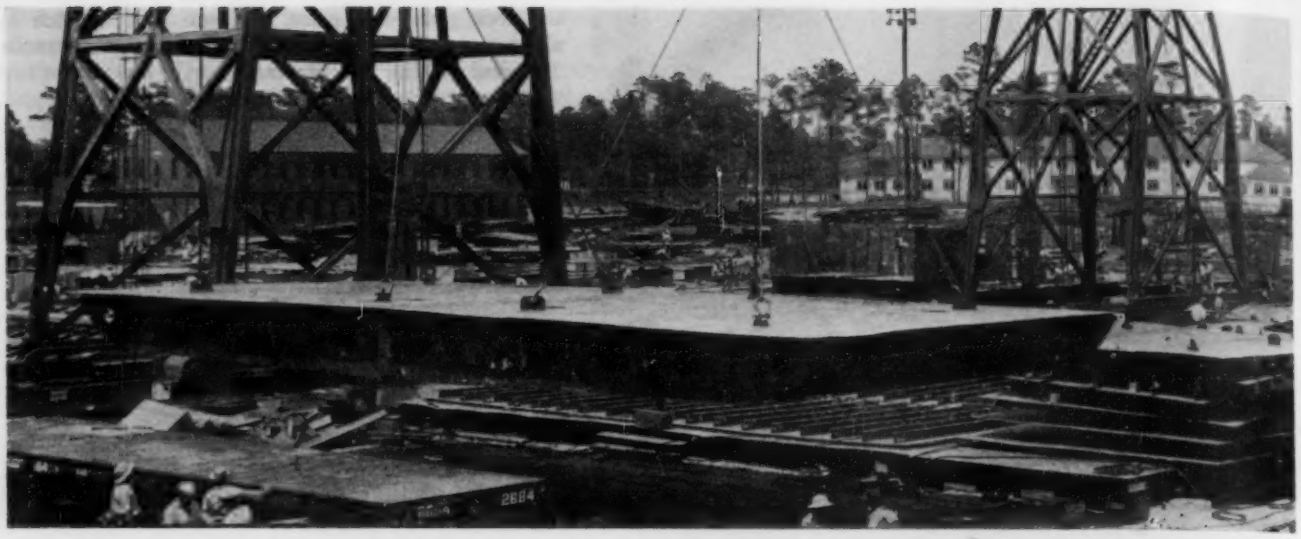

Fig. 6—Completed Section of Double Bottom. Intercostal Girder Plates Shown Tacked to End Floor Will Be Fitted and Welded After Erection of the Section

and sequence of welding in one particular yard, that of the North Carolina Shipbuilding Company at Wilmington, N. C., is outlined at some length as being fairly representative of most of the others. Mention is made later of outstanding differences in the practice of the other ten yards which had completed Liberty ships up to the time this paper was submitted.

North Carolina Shipbuilding Company

In this yard, the principal sub-assemblies fabricated on the ground are the bulkheads, double-bottom sections, deck and side shell panels, tunnel, deckhouses and the bow and stern assemblies; the hatch end beams, side girders and coamings for each hatch are also erected as a unit. These sub-assemblies are outlined in Figs. 2 and 3 and are also illustrated by the photographs shown in Figs. 4 to 16, inclusive, which, with the aid of the captions, should be self-explanatory. The platens, 13 in all, are mostly located in front of the nine building ways and are constructed of flat plates having drainage holes at close intervals. The principal sub-assemblies are put together on these platens with the exception of the side shell panels which are fabricated on open skids made up of steel rails supported on heavy timbers in order to afford access for riveting. Machine welding is used in sub-assembly work as far as practicable.

The main watertight bulkheads are assembled in separate units the full breadth of the ship and in height extending from the tank top to the second deck and from the second deck to the upper deck, the largest unit weighing about 24 tons. Deep-tank bulkheads and center line bulkheads in holds are also fabricated units. The bulkheads in holds are also fabricated units. The bulkhead plates are first laid edge to edge on the platen, stiffener side up, placing steel strips about 2 in. by $^1/_8$ in. under the joints to be welded and dogging down the plates at the edges in way of joints. The butts and seams are then tack welded with welds 1 in. long, spaced about 12 in. apart for plates over $^3/_8$ in. thick, and with $^1/_2$-in. tack welds at about 8-in. intervals for the thinner plates. The butts are welded first, then the seams, both by the Unionmelt process, the squared plate edges being separated by a gap of from $^1/_{16}$ to $^1/_8$ in., depending upon the thickness of the plating. The stiffeners of I-section on the main bulkheads and inverted angles on the 'tween deck bulkheads are next laid on the plates, tack welded in position and then machine welded with double continuous fillet welds in the case of the main bulkheads and by manual intermittent welds for the lighter material of the 'tween deck bulkheads. The boundaries are cut by means of a gas torch from permanent markings on the platen and the whole assembly turned over, after which the joints are blown out by an air hose and machine welding applied to the smooth side starting with the butts. Wood ribbands are bolted to the stiffeners across the bulkhead to provide the necessary stiffness for handling. Small doublings are welded over lifting holes at the top of the stiffeners for erection purposes.

The deck panels are assembled using the same procedure and sequence of welding as outlined in the foregoing for the bulkheads, but the beams are generally manually welded with intermittent welds. The arrangement of deck panels is shown on the deck plans, Fig. 3, the largest section being 48 ft. by 19 ft. 6 in. and weighing about 15 tons.

The double bottoms are prefabricated in 18 sections the full width of the vessel, the sections varying from 9 ft. to 27 ft. in length and weighing up to 41 tons. The inner-bottom plating is laid upside down on the platen and prepared in the same manner as for bulkheads and decks and

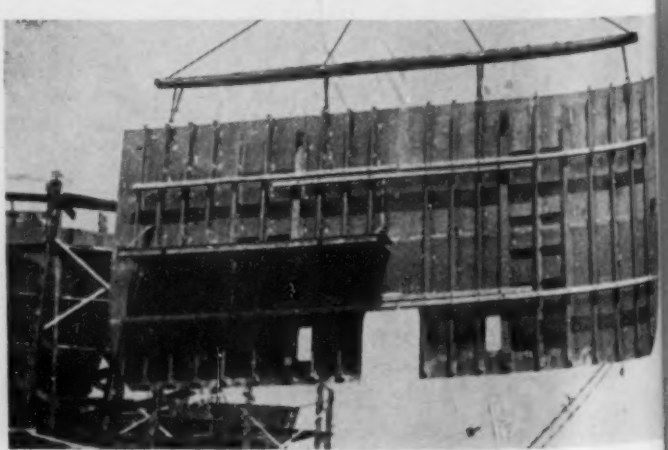

Fig. 7—Main Bulkhead at Frame 108 Shown with the Generator Flat Attached

then Unionmelt welded. The center vertical keel, floors and intercostal side girders are set up on the inner bottom and welded together by continuous manual fillet welds, after which they are welded to the inner-bottom plating. While the section is still inverted, the piping is installed and completed as far as possible, after which the entire unit is turned over and the butts and seams of the tank top machine welded.

The side shell between the collision and after-peak bulkheads is assembled in panels made up of the three strakes above the bilge in 13 sections varying from about 20 ft. to 30 ft. in length, and the sheer strake and topside strake in 8 sections (see Fig. 3), the average weight of panels being about 14 tons. The flat panels amidships are assembled by laying the frames on skids about 4 ft. above the ground and service bolting the shell plates in position, the edges having been previously bevelled to a 45° included angle outside for Unionmelt welding and a 60° angle inside for manual welding. The welding is first completed in the overhead position on the manual side and the butts and seams then Unionmelt welded on the outside, the butts being welded in every case before welding the crossing seams. When welding the seams the machine is slowed down and the current increased when crossing the frames in order to ensure proper penetration. The rivets connecting the frames to the plating are driven last.

Toward the ends of the vessel where the side plating has considerable shape the frames and plating of as many as four adjacent erection units are laid together over prepared plate forms and bolted in position (see *A*, *B*, *C* and *D*, Fig. 3). The plate edges in these areas are prepared as for manual welding with a 60° vee having no shoulder or root face. One manual bead is laid in the bottom of the vee from the top or outer side and the frame rivets are then driven. The assemblies are next cut into their component erection panels in order to facilitate machine welding, removed from the forms and set down on the skids in the reverse position with the frames on top. The first bead of manual welding is chipped to solid metal and the sealing manual bead applied on the inside surface. The panels are again turned over and the butts and seams welded by Unionmelt, each weld being made in approximately the flat position by adjusting each section to provide the minimum slope. The additional cutting and welding involved in this procedure is necessitated by the fact that the material for most of the Liberty ships had been ordered in bulk for assembly by individual plates, but it is claimed that there is an ultimate saving in welding time and costs by this extended application of machine welding. Tests show that the riveting is not disturbed by performing the major welding after the rivets have been driven.

The bow assembly comprises the collision bulkhead, the forward portions of the upper and second decks, the stores flat, the chain locker and the center line swash

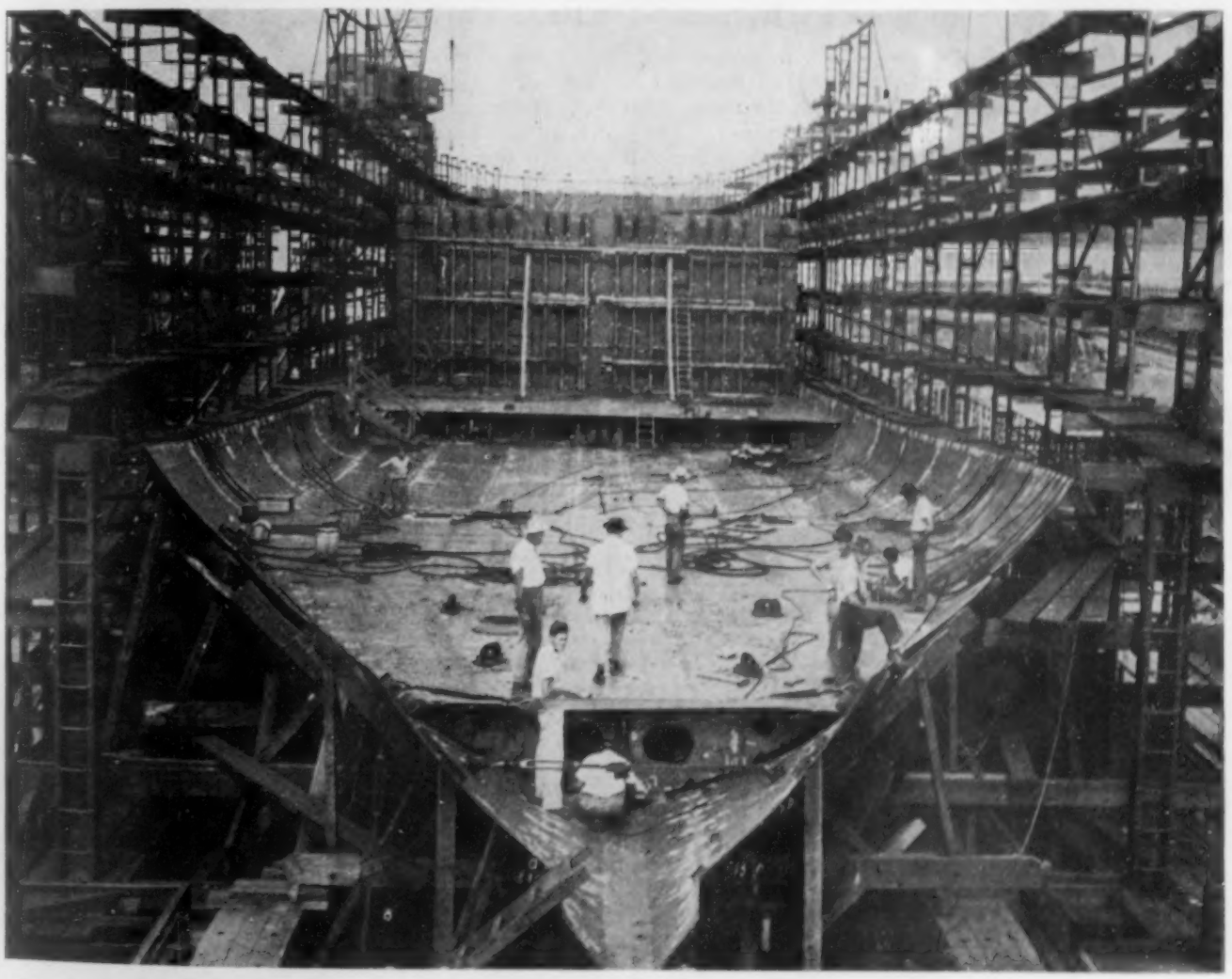

Fig. 8—View Looking Aft Showing Double Bottom Amidships and One Bulkhead in Place. The Forward Section of Double Bottom Is Being Fitted

Fig. 9—Shaped Lower Side Shell Assemblies Being Riveted on Forms After Which They Will Be Cut Into Panels and Removed to Be Positioned for Machine Welding of Butts and Seams

bulkhead, all of which are preassembled, as described in the foregoing paragraphs, together with the stem, forepeak, framing, shell plating and hawse pipes. These parts are assembled clear of the ways, bolted together and the shell seams and butts manually welded, after which the frame rivets are driven. The bow assembly is separated at the second deck into two sub-assemblies in order to facilitate erection as the upper and lower sections each weigh about 47 tons. The principal stern assembly includes the stern frame and is fabricated in a somewhat similar manner; the stern abaft the transom is likewise assembled on the ground.

All deckhouses are sub-assembled complete on platens and erected in place as units where practicable. The large superstructure amidships is separated into sections, the house on the upper deck into two athwartship sections each weighing approximately 38 tons and the two tiers of houses above the boat deck in one section weighing approximately 60 tons.

Actual construction on the ways is commenced by laying the flat keel plates on the blocks and machine welding the butts. The individual bottom shell plates are then laid on spauls arranged transversely to form a cradle, the plate edges having been prepared with a 45° bevel on the inside and a 60° bevel outside. The plates are lined up by dogs on the top surface and the initial manual bead laid from below in the overhead position in four butts of *A* strake, starting from amidships, and next in the seam between the *A* strake and the keel strake. The dogs in this vicinity are then removed and the butts machine welded from the top in the same order, after which the seam between the keel and the *A* strake is machine welded, starting from aft and working forward, all welding being carried out on both port and starboard sides simultaneously.

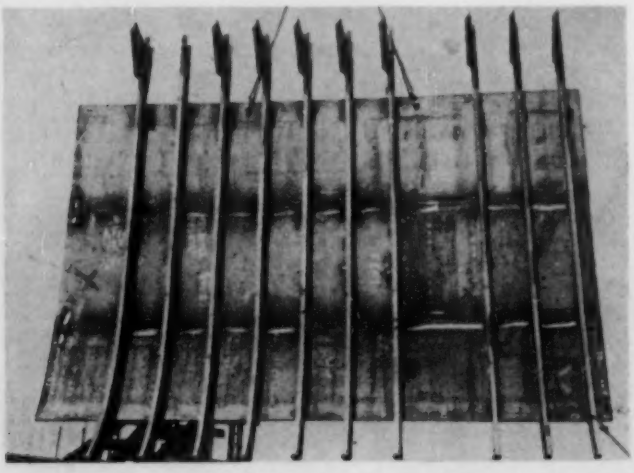

Fig. 10—Panel of Side Shell Plating with Frames Ready for Erection. The Missing Frame Is in Way of the Hatch End Beam, and Has Been Erected Separately

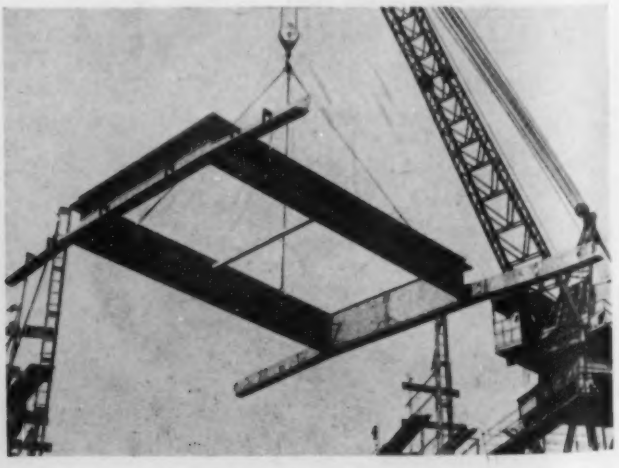

Fig. 11—Typical Sub-Assembly of Upper Deck Hatch Coaming and Hatch End Beams

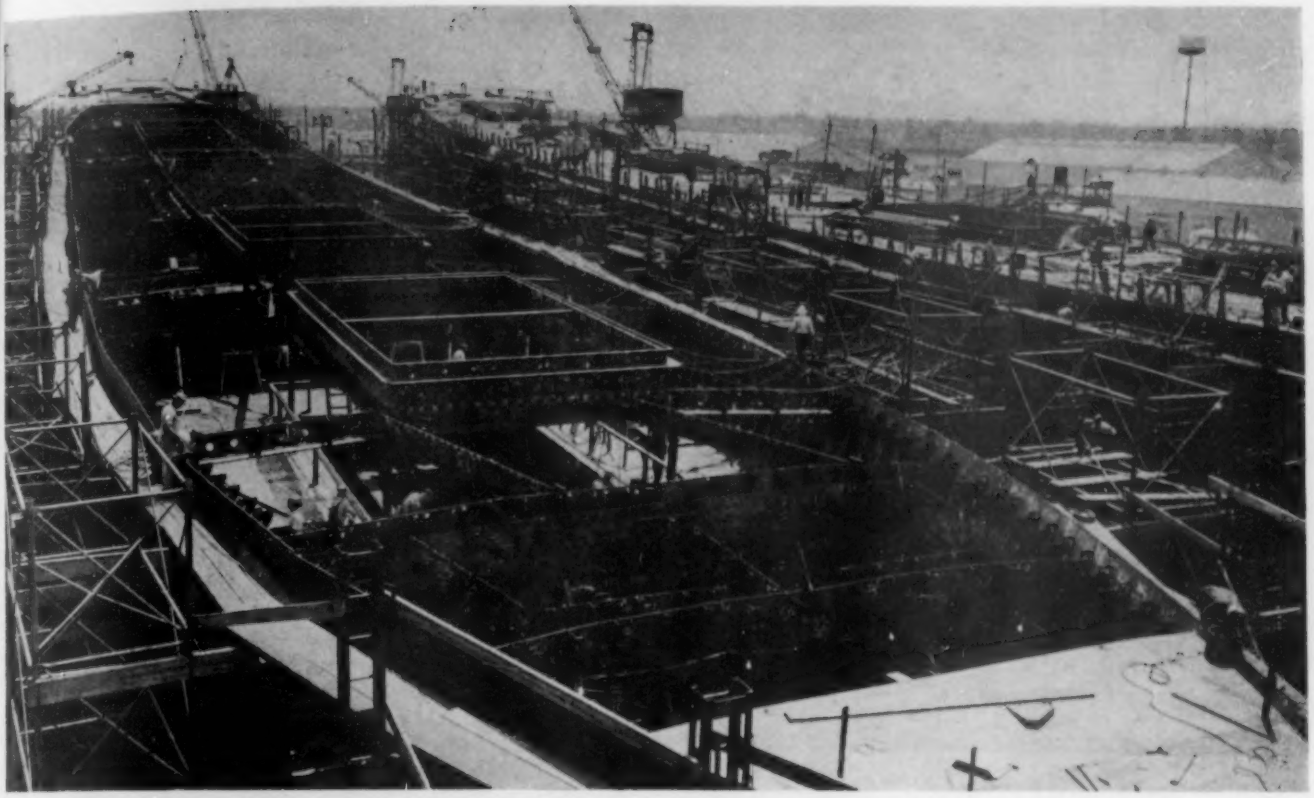

Fig. 12—Looking Forward at Upper Deck. Hatch Coamings and Girders in Place Ready to Receive Deck Panels of Plating and Beams

Three butts in the *B* strake are similarly welded, followed by the seam between the *A* and *B* strakes; two butts of *C* strake are welded, then the seam between the *B* and *C* strakes, and so on, the machine following in the same general order and direction as the manual welding, care being taken to weld all butts before welding the crossing seams. The bottom plates completely welded at any one time to tend to form a diamond pattern. The welding of the remainder of the plating follows in a similar sequence, alternating forward and aft of amidships as one plate length is completed. The distortion resulting from this method of welding is not sufficient to prevent easy fitting of the double-bottom assemblies to the bottom shell.

When sufficient bottom plating has been welded, the sections of double bottom are placed in position, starting amidships, all welding of floors to the shell being completed on each section before the adjacent section is fitted in place. The inner-bottom butts between sections are welded by Unionmelt, using a 30° bevel joint with a manual sealing bead on the underside. This bevel is all cut from one edge, the extra stock on the adjacent section being cut off square on the ways.

Fig. 13—Transom Section of Stern Assembly Ready for Erection. Numerous Bulkhead Assemblies Are Shown in Foreground on the Platens

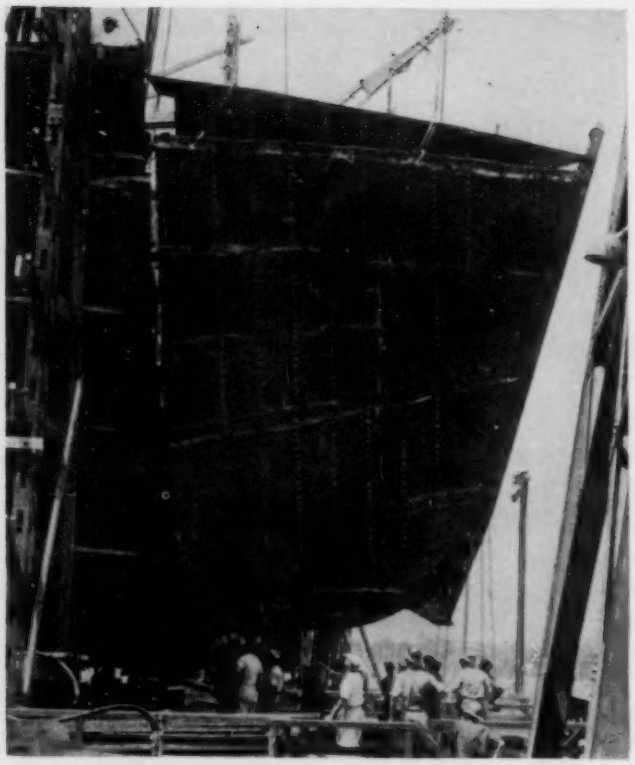

Fig. 14—Lower Section of Bow Assembly Being Fitted in Place

Commencing with the engine-room bulkheads, the bulkheads which extend to the second deck are erected in place on the completed sections of double bottom, scribed to fit the inner bottom, trimmed off and welded to the tank top. Other internal assemblies, such as fuel-oil settling tanks, center line bulkheads, flats, hatch end frames, deep tanks, stern structure and shaft alley, are erected as the preceding structure is completed, and welded as soon as they have been properly fitted in place. The lower panels of side shell with attached frames are next erected, starting from aft, being followed by the sub-assembled second deck hatches and girders, which are then joined to the center line bulkheads and hatch end frames. The center panels of second deck plating with beams attached are next set down on the bulkheads and girders and joined as they are fitted, beginning amidships and working forward and aft. The remaining lower side shell panels are erected in place prior to installation of outboard second deck panels, as is the lower bow assembly. The shell plates not included in the sub-assembled panels are fitted and welded in a somewhat similar sequence to that already described for the bottom plating. The main transverse bulkheads are welded to the shell after the hold frames have been welded to the inner bottom, second deck, flats, etc. The sub-assembly butts in the shell at both forward and after ends are welded last.

When the bulk of the welding has been completed up to the second deck, the 'tween deck bulkheads are erected, followed by the upper shell panels, starting from amidships and working aft, then forward at about the same time that the transom and upper bow assemblies are being erected. The box hatch assemblies and girders in way of the upper deck are then set up and the upper deck panels laid in the same order as for the second deck panels. The welding sequence for the upper 'tween decks starts with the joining of the upper deck units, after which the 'tween deck frames are welded to the decks; the shell plating is next welded at the assembly butts, and then the butts and seams of the shell plates at the ends are welded; finally, the 'tween deck bulkheads are welded to the surrounding structure.

Conservation of electrodes seems to have received careful attention at this particular yard. Welders are required to burn off each electrode to a 2-in. stub and before receiving a further supply their stub ends are weighed to detect any wastage of rods. An appreciable saving in electrodes has resulted from the adoption of this system.

It might be mentioned that the North Carolina yard uses propane gas in lieu of acetylene for flame cutting purposes, this highly volatile petroleum derivative being accumulated in storage tanks and distributed throughout the yard by a system of piping terminating at convenient locations.

General Practice

Ship welding has made possible the fullest use of prefabrication of sections, the size of which is limited only by the capacity of the shipyard cranes, so that the building of the ship on the ways is largely a matter of putting together the various sub-assemblies with a consequent increase in the building capacity of each way. The prefabrication of the entire group of midship deckhouses as one unit, having a total weight of about 150 tons, by the Kaiser Company's Vancouver yard constitutes the heaviest and certainly one of the most interesting sub-assemblies in the Liberty ships. The unit, as shown in Figs. 17 and 18, comprises not only all midship deckhouses but also includes every item of equipment, furnishings, wiring, plumbing, panelling, interior decoration and painting, etc., so that upon arrival at the end of the assembly production line it is complete in all respects and ready to be lifted and installed in its proper position on the finished hull by means of the crane equipment specially designed for this purpose.

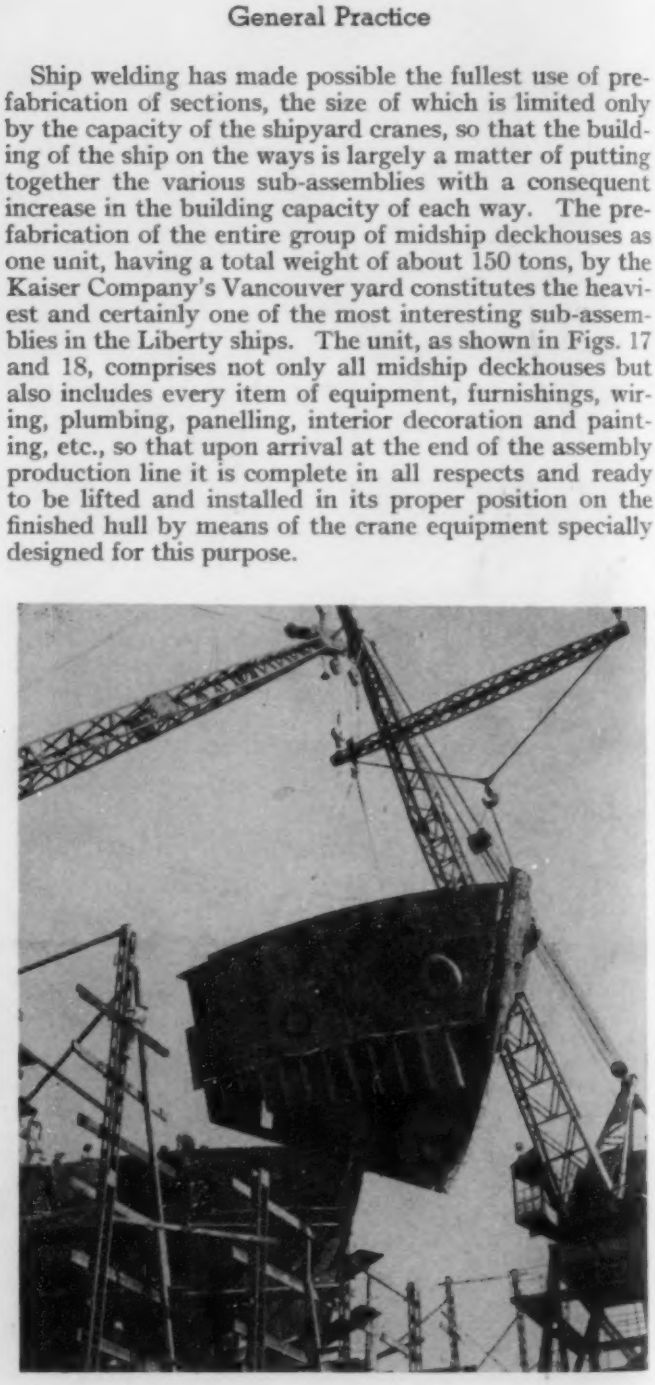

Fig. 15—Upper Section of Bow Assembly Being Erected in Place. The Lower Section, Partly Shown, Has Already Been Placed

It is common practice in all yards building Liberty ships to assemble the double bottom in sections, some of which are half the breadth of the ship although more often they are the full breadth weighing up to 40 tons One yard erects the double bottom in port and starboard sections about 15 ft. long, with the center vertical keel and its rider plate erected separately. Double-bottom sections are usually completely welded before being set in position on the bottom shell, the plates for which have been previously laid on the supporting cradles and welded together.

In another yard the flat portion of the bottom shell is assembled into panels, taking in *A*, *B*, and *C* strakes for two plate lengths in each panel, the plates being machine welded on both sides. These panels are not welded to the keel until the double-bottom sections are welded in place. In several yards the automatic welding of the top pass of the inner-bottom plating is left until after the section has been placed in final position.

The main transverse bulkheads are invariably fabricated on the ground and when erected in place on the inner bottom establish definite points between which the side framing and side shell plates can be regulated. In two yards the frames are welded to the shell plating and in one of these yards the shell seams are riveted, the shell butts being welded before adjacent seams are riveted.

Decks are generally fabricated in panels on the ground, the beams and girders being welded to the plating in the inverted position, the unit then being turned over and the seams and butts of plating completed on top, usually by the automatic process. It is interesting to note that in one of the yards the decks are laid in individual plates.

The extreme ends of the vessel are usually assembled on the ground in one or two sections and joined to the ship as units, a procedure which permits the bulk of the welding in these confined spaces to be positioned and thereby facilitated. When the bow and stern sections are prefabricated, they are generally welded to the main hull toward the end of construction.

One of the most difficult problems to be solved in building welded ships is the distortion and contraction resulting from the heat of welding so that care has to be taken to ensure that the finished vessel will conform as closely as possible to the designed dimensions.

Surveyors' transits are used during construction to check the straightness of the keel, and the over-all dimensions are likewise checked from time to time. On a number of completed vessels, lengths have been recorded varying from $3^1/_2$ in. longer to 9 in. shorter than the designed length, while breadths vary only $^1/_2$ in. at most and depths a maximum of $^5/_8$ in. from the molded dimensions.

In the matter of welding technique there are such variations in yard procedures as to indicate that satisfactory answers to all our ship welding problems cannot be immediately set up. It is the practice in all the yards to lay down a welding procedure with instructions that the procedure be adhered to until changes found to be desirable in the light of experience are definitely approved. Careful attention is given to the order of erection and welding sequence with a view to minimizing distortion and shrinkage stresses, the common procedure being to start amidships and work forward and aft and from the center outboard, making the corresponding welds on port and starboard sides simultaneously. On the side shell, welding generally proceeds from amidships toward the ends and from the bottom upward, the lowermost seam being kept ahead of the next seam above it, the butts being welded as they are reached, and so on. In some yards the first seam above the bilge is left unwelded until the welding above is completed; in others, butts around the entire girth, at about the quarter lengths, are left to be welded last.

The keel is anchored firmly to the ground against lateral and vertical movement by wire ropes or steel flat bars; the double-bottom units are sometimes held down by heavy concrete blocks during welding to the bottom shell. Extra stock is left on all prefabricated assemblies to be cut off finally after no further contraction can take place, and plates have an allowance made in their length

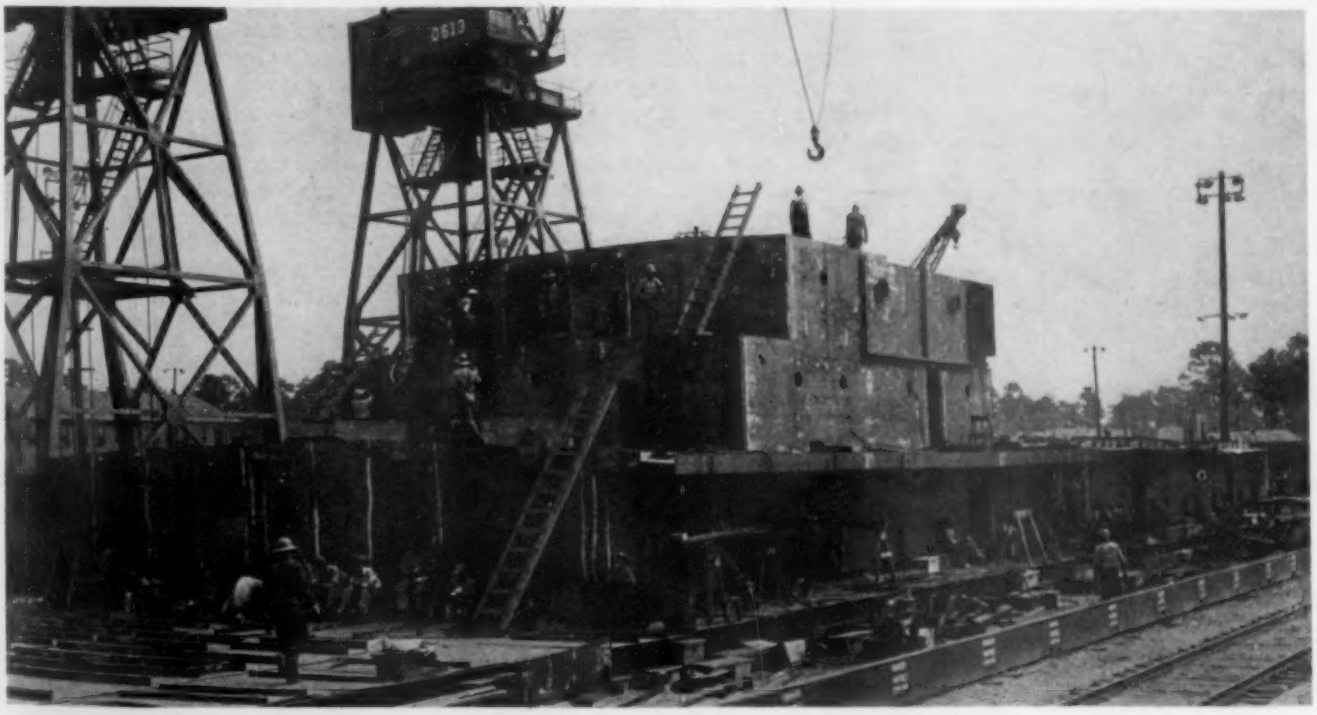

Fig. 16—Midship Deckhouses Being Assembled on Platen. These Will Be Separated Into Three Sections for Erection

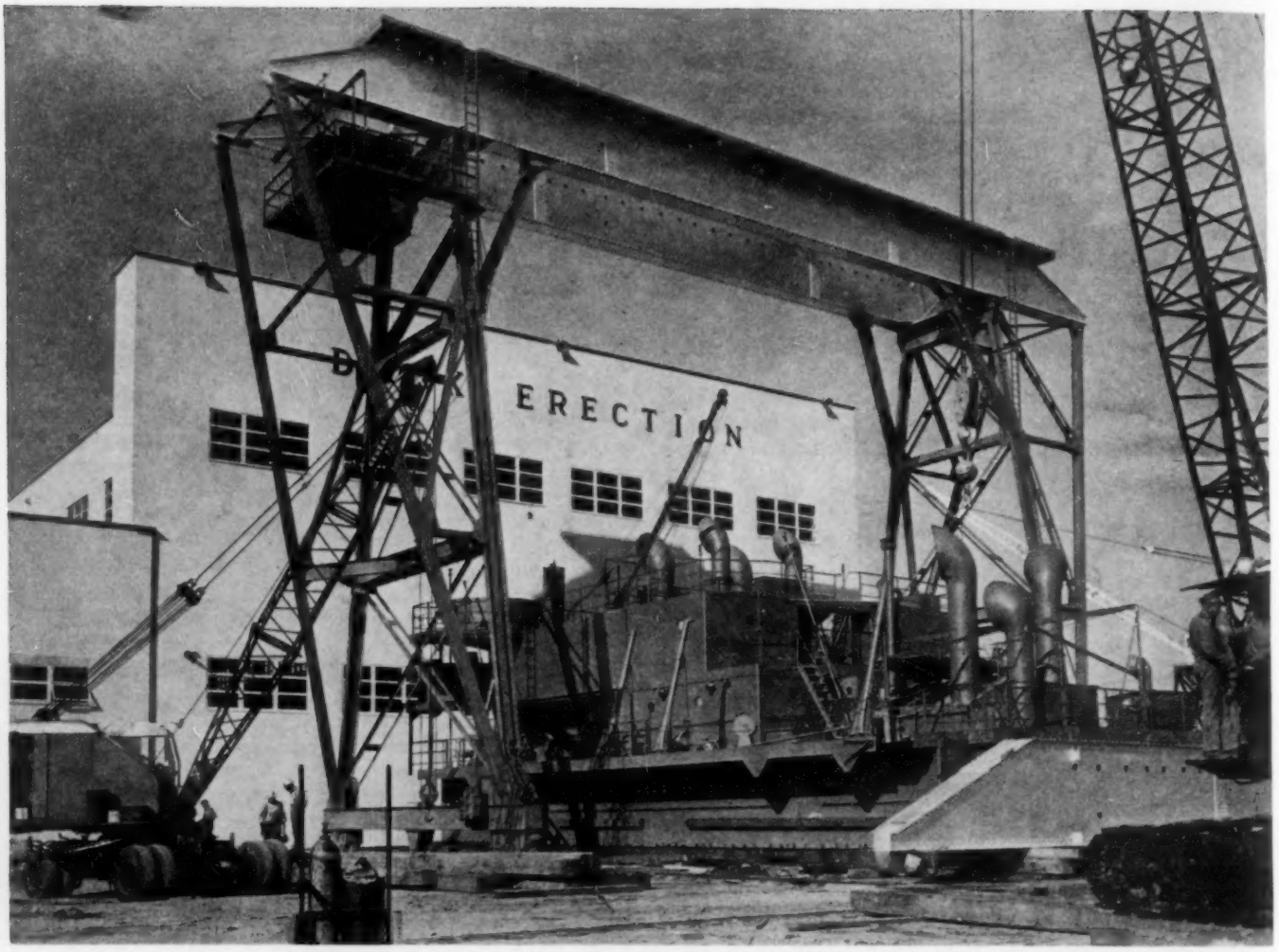

Fig. 17—Deckhouses, Kaiser Company, Inc., Vancouver

for shrinkage at the welded butts. In general, contraction is anticipated and compensated for in advance as far as practicable. By the use of large deck panel assemblies, relatively little deck welding is left to be done on the ship so that the contraction resulting from welding is not usually sufficient to lift the ends of the vessel from the keel blocks to any serious extent. In one yard, however, the keel blocks are set with a slight camber for about 30 ft. from the ends so that the keel will be straight after welding the shell and decks.

Unlike many shop applications of welding the conditions under which ship welding is performed vary considerably, some of them, such as weather conditions, being beyond the control of the shipbuilder. Even sub-assemblies cannot be stress-relieved and many of the principal strength welds must necessarily be made in the open. Sub-assembling enables much of the welding to be done in the downhand position in the shop under ideal conditions but there are many important field joints which necessarily must be welded in the overhead position and where efficient supervision and inspection are necessary to obtain the best results, especially in times like these when rapid production is so essential.

The use of the step-back method of welding is favored by most shipbuilders, others using straight welding or a block system, sometimes varying these with a wandering sequence, all with a view to minimizing shrinkage stresses in the structure. One practice, which seems to have unanimous approval, is that of welding the butts between plates before welding the seams which cross them. In manual welding the root of the weld is invariably chipped before applying the closing beads on the opposite side. This is essential for good workmanship, and that form of joint which can readily be chipped out is more likely to result in uniformly sound welds.

The welding equipment used by the various yards is representative of the entire field of manufacturers. There are many and various types of electrodes in use but all have been tested and approved for the type of welding for which they were designed. The constant-potential machine is sometimes used for assembly welding on the skids and in the shops, but the single-operator portable direct-current set seems to be popular in all the yards.

Joints

The number, location and type of welded joints are important matters for consideration in the initial stages of design. The number of joints should be kept to a minimum, their location should be such that they are easily accessible for welding, especially if they are field welds, and the joints should be so designed as to provide the desired strength with the least amount of deposited weld metal. The preparation of the plate edges will depend upon the type of joint, the thickness of the plates to be welded and whether manual or machine welding is to be used. No edge preparation is necessary with lap joints and the plates are easily fitted and regulated which accounts for some builders still preferring this type of

joint, especially for the smaller vessels. The flush joint which eliminates the necessity of fitting frame liners or any joggling of plates or framing has other obvious advantages, including superior strength, and has now become almost universal practice. The welding specifications issued by the Bureau of Ships, United States Navy Department, illustrate every conceivable type of joint and serve a useful purpose, since these are, in practice, considered typical joints which are acceptable rather than mandatory. Experience goes to show that even in an ordinary vee butt joint designed for manual welding the details of the groove with respect to angle of bevel, gap and root face can be varied appreciably without affecting the efficiency of the joint, provided the welding technique is adapted to the change.

It should be emphasized that excessive convexity of face should not be considered a reinforcement. It is undesirable as well as uneconomical, as the abrupt change in contour tends to cause an uneven distribution of stress in the joint and concentrate stresses at the edge of the groove. In the preparation of joints for welding there is a divergence of views as to the best way of making a particular connection. The same general type of joint is made with a shoulder or root face by one yard and with no shoulder by another, or one yard may prescribe a minimum gap and another prefer no gap at all. There appears to be no design of joint in ordinary use with which a good weld cannot be made by skilled hands. although some may offer a better assurance of good workmanship under actual shipyard conditions than others. Plate edges are commonly prepared by the oxyacetylene torch, usually with automatic carriage, to the exclusion of planing edges. Since a bevel with shoulder involves two cuts of the torch, welding methods in association with square plate edges or without shoulders are being constantly devised and tested.

The photo-macrographs shown in Figs. 19 and 20 were prepared in the American Bureau laboratory from the many samples received from our surveyors stationed at the different yards. The samples were chosen without special selection other than for type and were welded under conditions of current, position, etc., corresponding to the particular application in the ship. The samples were cut, polished, etched with 10% nital and photographed actual size although the reproductions are only half size. The sketch directly below each macrograph shows the plate edge preparation for welding the various joints.

All the joints shown in the left-hand column of Fig. 19 are manually welded, sketch A being the common 60° vee groove with a shoulder or root face. Sketch *D* shows the same joint with no shoulder, the absence of which it is claimed facilitates chipping of the root although apparently a sound weld can result from either method. Sketch *G* shows the double vee groove used to save weld metal and to minimize distortion by balancing the welding; the particular specimen selected was made in the vertical position as in a side shell butt. Sketch *K* shows a joint designed for use on the horizontal seams of side shell plating; this specimen was welded on the root side first and the presence of the void, which shows clearly in the macrograph, indicates a lack of proper chipping prior to welding.

The center column of Fig. 19 illustrates various methods of preparing plates for machine welding from both sides in sub-assemblies where the work can be turned over The smaller reinforcement or convexity of the finished weld, which results from the use of a suitable gap between the plates, will be noted by comparing sketches *B* and *E*. Sketch *H* shows one method of welding plates over $^5/_8$ in. thick, this particular thickness being the maximum so far approved for machine welding with squared edges butted close together. Sketch *L* illustrates the type of joint with two initial manual beads laid in the bottom of the groove and it will be noted that the manual beads have been absorbed by the subsequent passes of machine welding from each side of the plate.

The right-hand column of Fig. 19 shows some examples of joints which were welded from one side by machine and the other by hand as applied to bottom shell plating on the ways and to the field joints of deck panels. It will be noted that the edge preparation for joints *F* and *G* is similar; these two samples came from the same shipyard, this type of joint being adopted with a view to providing that simplicity resulting from preparing the butts of all shell plates alike, Sketch *J* is similar to sketch *L* in that manual beads are laid in the bottom of the groove in the downhand position prior to machine welding.

Manual and machine welding of the tank top to the

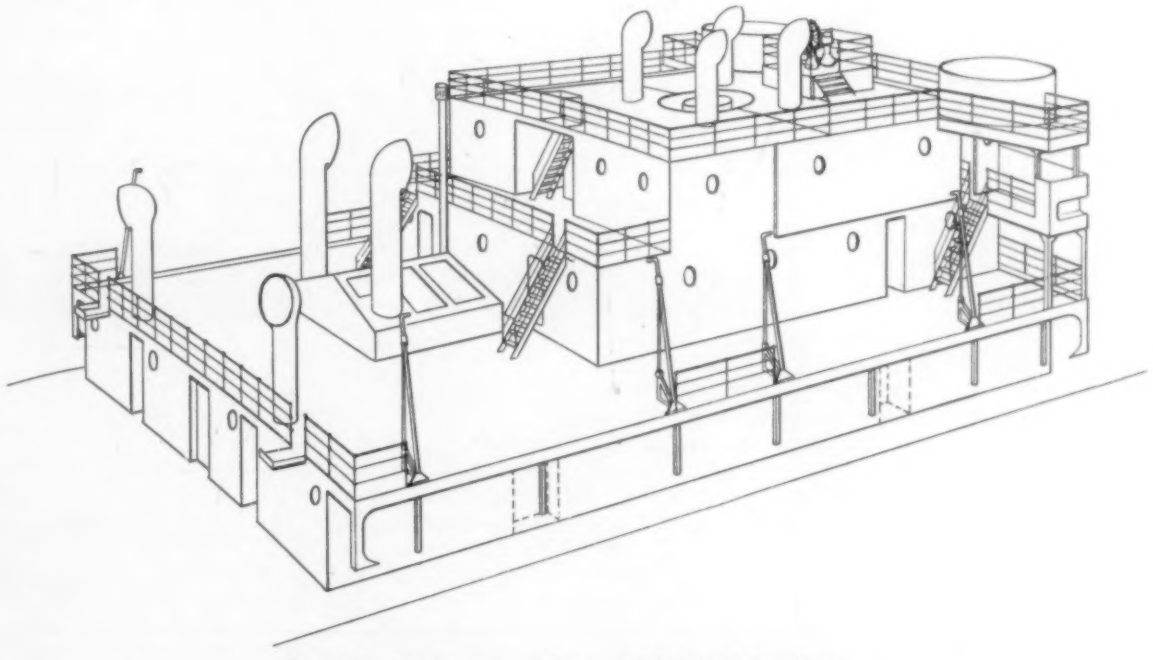

Fig. 18—Perspective View of Midship Deckhouse

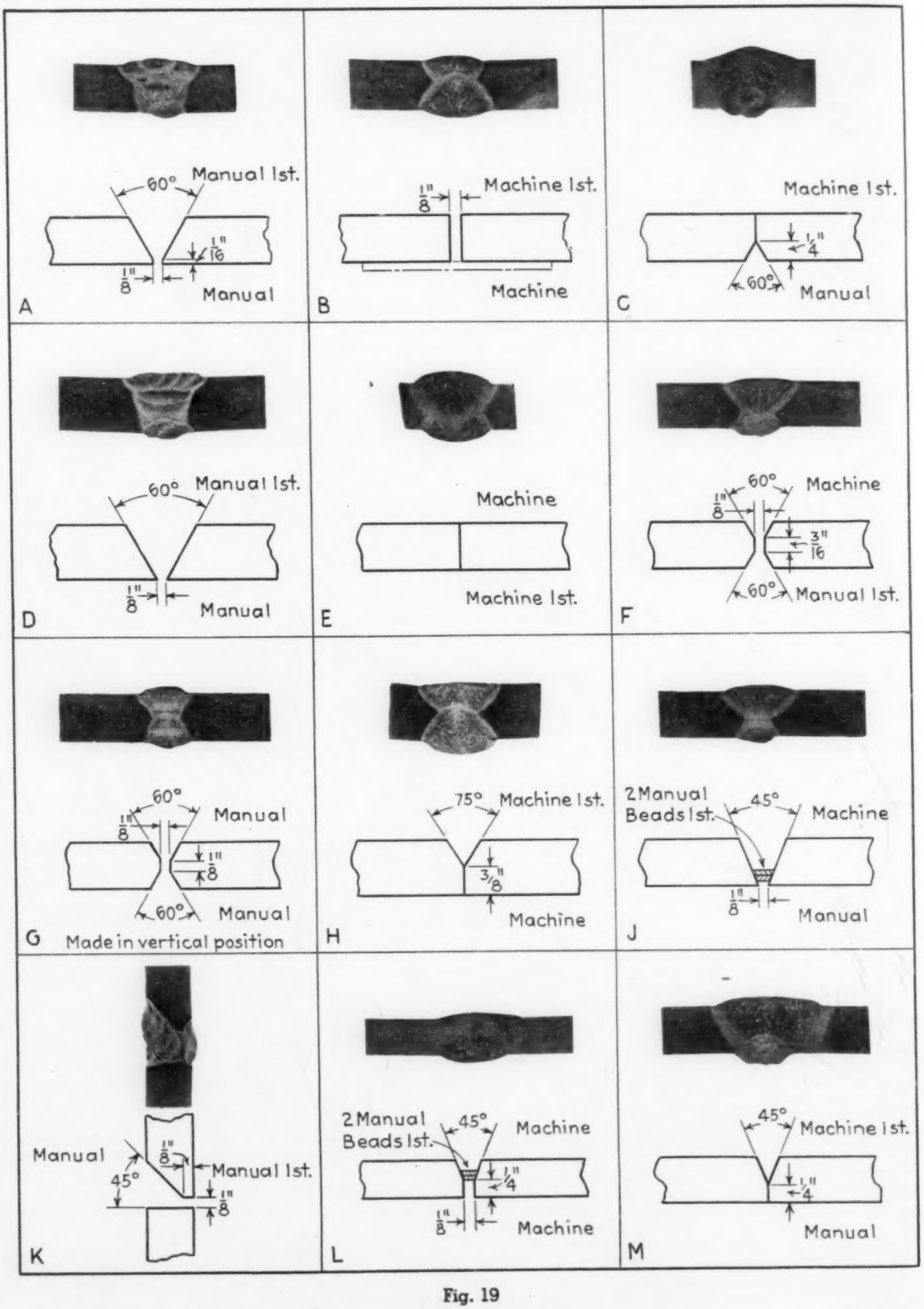
60° Manual 1st.
1/8"
1/16"
Manual
A
1/8"
Machine 1st.
Machine
B
Machine 1st.
1/4"
60°
Manual
C
60° Manual 1st.
1/8"
Manual
D
Machine
Machine 1st.
E
60°
Machine
1/8"
3/16"
60°
Manual 1st.
F
60°
Manual
1/8"
1/8"
60°
Manual
G
Made in vertical position
75°
Machine 1st.
3/8"
Machine
H
2 Manual Beads 1st.
45°
Machine
1/8"
Manual
J
Manual
45°
1/8"
Manual 1st.
1/8"
K
2 Manual Beads 1st.
45°
Machine
1/4"
1/8"
Machine
L
45°
Machine 1st.
1/4"
Manual
M

Fig. 19

shell are compared in Fig. 20, sketches *N* and *O*, respectively. Sketch *P* shows how the upper deck stringer plate is usually bevelled for manual welding to the shell. On the ligher plating of the second deck no edge preparation is necessary in association with the machine welded fillet shown in sketch *Q*, where the deep penetration characteristic of machine welding is clearly indicated. Sketches *R* and *S* show manual and machine welding, respectively, as applied to an ordinary double fillet tee joint. Sketch *R* is an excellent example of a lamination in the vertical plate which has been opened up by the heat of welding; the superior penetration obtained by the machine is also quite apparent.

The macrographs *T* to *Y*, inclusive, shown in Fig. 20 were taken from samples made in a series of tests to compare fillet welds using an ordinary electrode with the corresponding welds using a high current or "hot type" electrode under widely varying conditions of current, burn off and speed of travel. The samples were made with direct current, straight polarity and under the conditions indicated in each case. The purpose of making these tests, which were carried out at the Federal shipyard under the supervision of our surveyors, was to determine optimum figures for current and speed of travel in association with this new fillet weld technique. Macrographs *T*, *U*, *W* and *X* show certain welds which are obviously unacceptable and it should be emphasized that these were arrived at deliberately as part of the investigation. Macrograph *V* shows four welds made by an ordinary covered electrode under ordinary conditions, and macrograph *Y* shows welds resulting from the use of the high current electrode under optimum conditions of current, etc. It will be noted that deeper root penetration and considerably higher welding speed were obtained with the "hot type" electrode. Several yards are already experimenting with this type of rod with a view to increased production and conservation of electrodes.

Automatic Welding

The use of automatic machine welding has been gradually extended in our shipyards with a view to reducing the amount of manual welding and the time required for fabrication. The shortage of experienced welders is another impelling reason for the growing popularity of machine welding.

The majority of yards use the Unionmelt process for all seams and butts which can be welded in the flat position on the ground and in varying degrees on the ship limited by the ability of the machine to function only on surfaces which are flat or have slight inclination or curvature. Two yards have not used any automatic welding at all up to the time this paper was prepared and one yard employs the machine only on sub-assemblies in the shop. The flat portion of the bottom plating is generally welded by machine on the top side in association with a manual weld below. In two yards the welding of bottom seams and butts is done by machine on both sides, in panels of six plates which can readily be turned over.

A number of applications have been made of machine welding of fillets in such locations as the deck connections to the shell and hatch coaming, the inner bottom to the shell and the center vertical keel to the inner bottom. Some use is also being made of the automatic machine for welding channel stiffeners to bulkheads by continuous fillets at the heel and toe of the faying flanges. Where machine fillets are substituted for manual fillet welds a reduction in size of the fillet is permissible on account of the superior penetration.

Many joints can be made advantageously by machine welding from the top where the work cannot be turned over and must be welded by hand from below. To reduce the amount of overhead welding the plate edges are so prepared as to permit the machine weld to penetrate to almost the full thickness of the plate, the hand weld on the bottom being in such cases more in the nature of a closing bead. The manual weld is sometimes made first to act as a backing for the machine weld and in other cases the bottom of the machine weld is chipped out and the manual bead deposited last, the latter condition requiring that the joint be laid up tight before welding or that a backing strip be used. In one yard, in addition to the overhead bead on the underside, two manual beads are laid in the bottom of the groove in the downhand position before finish welding with the machine. Where the work can be turned over, plates up to $^{5}/_{8}$ in. in thickness can be readily machine welded from both sides with adequate penetration without bevelling the edges and without using any backing strip, provided the plate edges are laid close together. Attempts to machine weld plates of greater thickness without edge preparation result in an undue amount of filler metal being piled up on the surface of the joint, although full penetration can be obtained in plate thickness of $^{7}/_{8}$ in. or even more. By separating the edges by a distance proportional to the thickness of the plate and backing up the first pass by flux in the bottom of the gap, the deposited metal can be made to fill the groove and leave only a reasonable reinforcement.

The advantages of automatic welding are better penetration, smooth appearance, less distortion and increased speeds where long straight welds can be made, especially in the thicker plates. Experience has shown, however, that to make a perfectly sound machine weld, the joint must be absolutely free from impurities and kept dry, otherwise bubbles will form in the metal and cause holes to appear on the surface which may extend deeply into the weld. It is good practice to clean the plate edges thoroughly with a power-driven wire brush and to dry out the joints in damp weather by passing a heating torch over them prior to welding.

Design for Welding

To get the most out of welding in ship construction the number of joints should be kept down to a minimum by the use of large plates and the fullest use should be made of available rolled shapes or flanged plates rather than by welding plates together to form the desired sections. Shapes specially designed for welded construction are still lacking but the advent of the cutting torch has facilitated the maximum use of commercial rolled shapes designed for riveting and which are now restricted in number to a point where it is difficult to achieve maximum economies in weight. Sub-assemblies should be as large as practicable with the individual yard handling facilities in order that a maximum amount of welding can be done in the downhand position, and field joints should be so located as to provide easy access for welding on the ship. An arrangement of deck panels whereby the welding in way of hatch corners can be done on the ground rather than on the ship is to be preferred in the interest of sound workmanship. It is always better and cheaper to weld on the ground rather than on the ways and welding in the flat position is the most economical. The adoption of a wider frame spacing than the normal will result in fewer parts to handle with less welding. Large manholes should be provided in floors and intercostals for easy access in double bottoms and other confined spaces; the fact that a welder wears a helmet is sometimes forgotten.

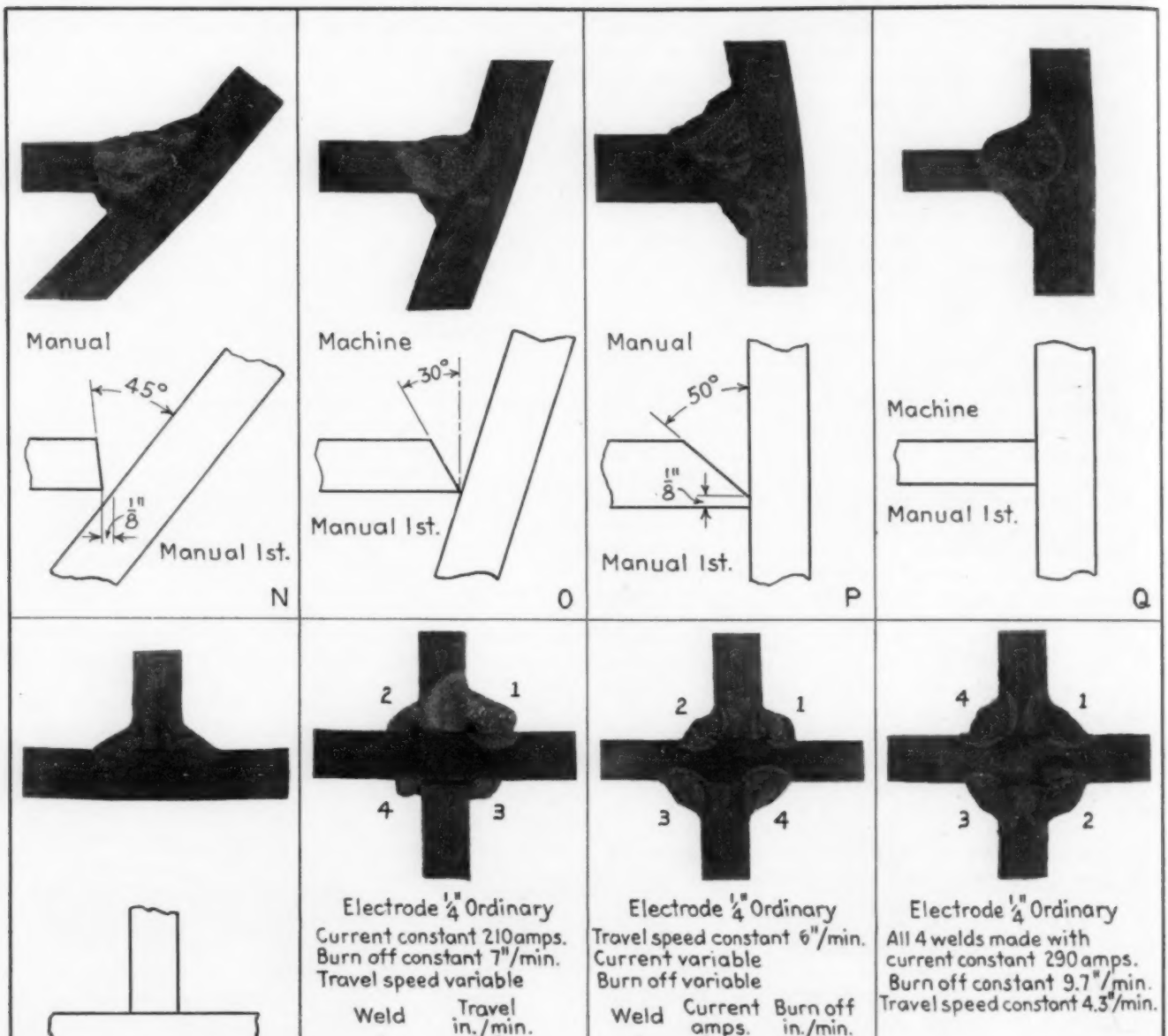
Manual
45°
1/8"
Manual 1st.
N
Machine
30°
Manual 1st.
O
Manual
50°
1/8"
Manual 1st.
P
Machine
Manual 1st.
Q
R
Manual
2
1
4
3
Electrode 1/4" Ordinary
Current constant 210 amps.
Burn off constant 7"/min.
Travel speed variable
Weld | Travel in./min.
1 | 2.0
2 | 4.7
3 | 7.3
T 4 | 12.0
2
1
3
4
Electrode 1/4" Ordinary
Travel speed constant 6"/min.
Current variable
Burn off variable
Weld | Current amps. | Burn off in./min.
1 | 210 | 6.8
2 | 255 | 8.6
3 | 340 | 11.2
U 4 | 375 | 12.2
4
1
3
2
Electrode 1/4" Ordinary
All 4 welds made with current constant 290 amps.
Burn off constant 9.7"/min.
Travel speed constant 4.3"/min.
V
S
Machine
1
2
4
3
Electrode 1/4" Hot Type
Current constant 270 amps.
Burn off constant 9.6"/min.
Travel speed variable
Weld | Travel in./min.
1 | 3.1
2 | 6.5
3 | 8.3
W 4 | 12.5
1
2
3
4
Electrode 1/4" Hot Type
Travel speed constant 12"/min.
Current variable
Burn off variable
Weld | Current amps. | Burn off in./min.
1 | 210 | 7.1
2 | 275 | 9.8
3 | 320 | 11.0
X 4 | 370 | 13.0
2
1
4
3
Electrode 1/4" Hot Type
All 4 welds made with current constant 340 amps.
Burn off constant 12"/min.
Travel speed constant 11.6"/min.
Y

Fig. 20

Training of Welders

The tremendous expansion of shipbuilding incidental to the emergency program found the industry with a serious shortage of experienced welders and it became necessary to train new men in large numbers. Government and State agencies set up schools in some localities or gave financial aid to existing trade schools. Most yards, however, have found it desirable to maintain their own schools where men who have not been previously qualified are given additional instruction to enable them to pass the necessary qualifying tests.

About half the yards have a regular course of instruction which takes, on the average, about 250 hr., during which lessons are given in welding the usual groove and fillet joints in the flat, horizontal, vertical and overhead positions.

Those yards which do not operate schools require new men to begin by tack welding under supervision and even newly qualified men sometimes receive further instruction while continuing to do actual work of comparative structural unimportance. While it would be desirable to have all tack welders qualified operators, the emergency has made it necessary to use to some extent inexperienced men for this work in order to release qualified welders for more important work. The urgency for training welding operators as rapidly as possible restricts the course of instruction in shipyard training schools to practical welding technique; i.e., current setting, length of arc, angle of electrode, speed of travel, etc., to the exclusion of the theoretical side of the subject which after all is more in the province of the welding engineer. Some welding schools make excellent use of movie films such as have been made available to the industry by the General Electric Company.

Electrodes used by trainees are the same as those used in production in all cases. When new electrodes with new techniques are introduced the welders are given additional instruction in their application before doing actual ship work. Where automatic welding is used, the operators are rarely qualified manual welders and are trained only in the use of the particular machines, usually as helpers at the beginning.

The supervision of welders is organized somewhat differently in the various yards but is generally built around the welding engineer with foremen in charge of one or more ships and with leadingmen in charge of portions of a ship, or of a certain number of welders, as few as 10 men in the case of one particular yard. While it would appear that men can be taught in a few weeks to weld with sufficient proficiency to pass the regular qualifying tests, a welder with some years experience will be more likely to make consistently good welds under shipyard conditions. With relatively inexperienced welders, the need for adequate supervision cannot be overemphasized.

Weld Quality Control

The question naturally arises as to how we can be assured of getting those sound homogeneous welds which are so desirable in ships' structures when it is not practical to X-ray the welds except here and there as check tests or to stress-relieve the work as is universal practice in the case of boilers and pressure piping. The main factors, not necessarily in order, which enter into the production of sound welds are the suitability of the welding equipment, especially the electrodes, the welding procedure, the skill of the individual welder, the suitability of the base metal for welding, and the competency of the yard supervisors and inspectors. Administrative authorities, such as the American Bureau of Shipping, exercise their control over ship welding by approval of electrodes, approval of welding procedures, qualification of welders and by competent supervision.

Approval of Electrodes

Considerable research has been carried out by American manufacturers of electrodes to improve the quality of their product with a view to ensuring deposited weld metal of the highest quality, with special emphasis on ductility, and makers are now able to furnish electrodes to meet all practical welding requirements. The electrode specifications issued jointly by the AMERICAN WELDING SOCIETY and the American Society for Testing Materials, and which are subject to annual revision, have also contributed to this improvement. These specifications classify the different types of electrodes on the basis of their usability; i.e., their capability of producing satisfactory welds in the flat, vertical, overhead and horizontal positions, and outline test requirements for the various classifications. There is a large variety of electrodes on the market, some for use with either alternating or direct current, some which do best in certain positions, and others which are designed for special purposes. From time to time the American Bureau of Shipping issues lists of approved electrodes which have undergone the prescribed acceptance tests; such electrodes can be depended upon to deposit satisfactory weld metal within the limits of their approval and when used with due regard to the instructions issued by the manufacturers. Welding engineers and even the welders themselves have their individual preferences for certain makes of electrodes but in general the position with regard to electrodes is satisfactory in that poor welding cannot usually be attributed to any lack of quality in the electrodes.

Qualification Procedure

The quality of a welded joint will depend not only on the suitability of the welding equipment, including the electrodes, but to a large degree on the particular welding procedure adopted, so that it is the practice for each shipyard to weld in accordance with a definite approved procedure specification which governs such essential factors as the amperage and voltage for each size and type of electrode, the type of joint, the number of passes or runs for each joint, etc. The routine commercial tests by which the soundness of a sample joint welded under a given procedure specification is determined are embodied in the American Bureau of Shipping "Rules" and in general conform to the standard qualification procedure tests recommended by the AMERICAN WELDING SOCIETY. Any important change in the many variables affecting welding procedures for both manual and machine welding, such as a change in the base metal, say from mild to high tensile steel, a change in the size and type of electrode, as, for example, the use of "hot rods" in association with the new fillet weld technique, and any major change in the type of joint, such as in the included angle of the welding groove, obviously necessitates further tests under the new conditions. Continuous experimentation along such lines by each individual shipyard is eminently desirable and should be encouraged, even though it may involve some duplication of effort.

Operator Qualification

Assuming that a procedure has been proved satisfactory, the remaining important requisite for the produc-

tion of sound welds is the skill of the individual welder. It is probable that undue emphasis has been placed on approval tests for welders to the exclusion of other factors, such as proper equipment, due to the lack of a positive means for testing welds comparable with the hammer testing of rivets, which by the way has decided limitations and is by no means an invariable criterion of a satisfactory rivet. It is the builders' responsibility to supply efficient workmen, including welders, and unfortunately this so-called qualification of welding operators tends to glorify an art which is purely mechanical and easily acquired as compared with some other trades. It is satisfactory, however, and to the benefit of the industry that these operator tests have been recently simplified and standardized, also that the various authorities having to do with shipbuilding, that is, the Bureau of Ships, the American Bureau of Shipping and the Bureau of Marine Inspection and Navigation, will now accept welders qualification tests witnessed by the representatives of any one of these regulatory bodies. The card issued to the employer certifying to the fact that a 'welder has passed certain specified tests should not be construed to mean that the welder has been granted a certificate of competency or be considered any guarantee that he is now able to weld anywhere and everywhere.

Base Metal

One important factor in the production of sound welded structures is the suitability of the base metal for welding. The chemical composition of a metal affects not only its physical properties but also its weldability; for example, the higher the carbon content in steel the more difficult it is to produce a satisfactory weld. The crystalline structure of the steel adjacent to the weld is affected by the extreme heat of the welding process and by the rate of cooling, rapid cooling tending to produce a brittle martensitic structure favorable to the formation of cracks, especially in the higher carbon steels. Preheating decreases the rate of cooling after welding and is an essential part of the technique of welding such steels, as is also stress-relieving.

While little difficulty is encountered in welding ordinary structural steel, there is still room for improvement in the steel being delivered to our shipyards. Freedom from laminations and excessive slag inclusions and from undue segregation of carbon, sulphur, etc., are important desiderata, if welding qualities are not to be sacrificed, and these involve the whole process of steel manufacture and such important questions as the relative suitability of rimmed, semi-killed and killed steels for ship structures. A revision of the various structural steel specifications should be undertaken as soon as possible after the emergency, preferably under the auspices of the American Society for Testing Materials, with a view to the preparation of a common specification for a structural steel of the highest weldable quality for use in ships, bridges, buildings and other large structures.

Inspection and Workmanship

The advent of welding in our shipyards has necessitated a higher degree of supervision and new inspection procedures requiring, one might almost say, a different kind of inspector. Unfinished welding is not so easy to discover as, for example, missing clips and rivets, and poor welding is more difficult to detect than inferior riveting or superficial calking. On the other hand, routine tank testing in a welded ship is much less onerous and it is seldom that ballast or fuel tanks require to be emptied for making good defects with subsequent retesting. Sound workmanship is the most economical job in the long run so that efficient inspection is entirely in the best interests not only of the owners but also of the shipbuilder. The type of inspector who, clothed with a little brief authority, interferes but does not facilitate, who lacks a sense of values with the inevitable tendency to stress items of comparative unimportance, who looks for reasons for rejection rather than for acceptance and whose discovery of admitted defects is invariably at that stage of the work where corrective measures are troublesome and costly, does not conform to the author's idea of an efficient inspector. The foregoing remark is prompted by the perusal of a pamphlet recently issued by the AMERICAN WELDING SOCIETY on the subject of "Inspection of Fusion Welding" in which the duties and desirable qualifications for a welding inspector are described at some length.

The use of the X-ray machine for detecting porosity, poor fusion, cracks, inclusions, etc., in welds as indicated in films after they have been developed is not very practical in ship structures and its application has been very limited. It is practical, however, to test flush welded joints by trepanning plugs large enough to include the full cross section of the weld, after which the plugs are ground, etched and examined for possible defects, and this method has been used occasionally on important joints in some yards. Inspection of ship welds is generally confined to a visual examination, which is more reliable than is commonly believed; a nice looking weld is usually a sound weld, although not essentially so. Undercutting can readily be determined by visual examination and a trained supervisor or inspector can recognize good welding by the characteristic "frying" sound and can judge proper penetration by the crater and the burn off of the electrode. Suitable current and welding speed for the size and type of electrode used should result in a smooth and regular bead to the exclusion of overlapping and undercutting.

Accurate cutting and shaping are essential to provide a good fit-up prior to tack welding. Tacking should be adequate to prevent cracking and individual welds should not be left to cool in an unfinished state. The removal of slag before applying succeeding layers is important for ensuring sound welds. Slag on the finished weld should, however, be left on until the weld has cooled completely, in view of its annealing effect. The clips and dogs required for proper regulation before tack welding should preferably be on the inside of the ship, if only in view of the unsightly scars which remain unless due care is taken in the process of removal.

Distortion

Distortion as evidenced by the buckling of plating and stiffeners, especially in light superstructures, 'tween deck bulkheads, etc., is one of the ever present problems of ship welding which is not easy to prevent and is difficult and expensive to correct, so much so that some shipyards where riveters were available have reverted to riveted construction for deckhouses, bulwark plating, etc., with a view to speeding up production. A serious initial deflection in the plating between the beams across the strength deck will tend to impair the efficiency of the ship's structure under compression, but the common objection to most of this buckling or warping is its unsightly appearance; certainly undue buckling in the deckhouses of a passenger ship does not conform with one's ideas of a shipshape job.

The amount of allowable distortion before requiring corrective measures constitutes a bone of contention be-

tween owners' inspectors and builders. The welding specifications of the Navy Department include a table of tolerances for distortion which is certainly not unreasonably severe and a similar table has recently been issued by the Maritime Commission for the guidance of their inspectors.

While a certain amount of buckling was not uncommon in light riveted construction, welding has certainly intensified the problem. Welding is not always entirely to blame, as a considerable amount of the trouble can be traced to careless and improper handling of prefabricated panels, which have little inherent stiffness and should be kept in shape by the use of strongbacks until welded to their supporting members. The plates as taken from the racks may already be badly buckled and should be stretcher straightened or mangled before being laid out on the platens. The platens themselves should be of substantial construction with a heavy plate base with adequate foundations to prevent subsidence.

Distortion resulting from non-uniform shrinkage and unbalanced welding can be reduced to a minimum by the restraint provided during the process of welding by the use of strongbacks, ribbands, dogs and heavy weights which have the effect of encouraging local plastic yielding. A proper welding sequence in association with skip welding will help to distribute the heat more evenly and thereby tend to reduce distortion. Excess welding and oversize welds should, of course, be avoided. Intermittent welds cause less distortion than continuous fillet welds, which, however, have the decided advantage in ship work of sealing the joints.

Cumulative distortion on the ship, as is sometimes evidenced by the keel rising from the blocks, can be kept under control by the sub-assembly method of erection. The structure of a deckhouse reduced to the simplest elements consists of plates stiffened by vertical inverted angles usually unattached at their ends. The use of large plates to cut down the amount of welding to a minimum is beneficial and a more complex system of framing whereby the plating is divided into small panels by the fitting of horizontal secondary stiffening members between and preferably attached to the vertical stiffeners will serve to keep distortion within reasonable limits. The use of small symmetrical shapes, if available, would also prevent the buckling due to lateral deflection of inverted angle stiffeners. The use of light corrugated plating for deckhouses and internal bulkheads, as is fitted in the Pullman cars of our streamline trains, has also been proposed with this end in view.

There are wide differences in the methods of removing buckles in plating in the various yards and considerable differences in the results obtained even where similar equipment is used. Flame straightening by the oxy-acetylene torch accompanied by quenching by water or air is the most popular method and is quite effective if properly carried out and not overdone. A common mistake is to overshrink by the application of too much heat and a combination of overheating and sudden quenching will damage a plate beyond repair. Considerable skill and experience are required in choosing the right spots to apply heat and to get results with a minimum expenditure of time and oxygen. Shrinking the plate by depositing lines of welding is another corrective measure which can be effective in eliminating buckles, although flame straightening is to be preferred in the opinion of the author.

Residual Stresses

Residual or locked-up stresses still remain the most important and controversial question among those responsible for the efficiency of large welded plate and shape structures which cannot be stress-relieved. It has been asserted that such stresses tend to distribute themselves when subjected to external loading and even to disappear in the course of time. It has also been authoritatively stated that "the critical time in a welded structure is a period of somewhat indeterminate length beginning immediately after the welded joint is made," all of which would be very comforting, especially if the word "limited" could properly be substituted for "indeterminate." We do know that these stresses are the inevitable effect of expansion and contraction resulting from the heating and cooling of the weld and adjacent base metal and cannot be eliminated entirely. Since they can only reduce themselves by the plastic yielding of the deposited metal and the parent material, the property of ductility both for the weld and base metals becomes of paramount importance. The application of the intense concentrated heat during the arc-welding process results in expansion of the base metal, followed by cooling and shrinkage of both the base and deposited weld metals. Stresses are thereby set up which are evidenced by distortion, the degree of which depends on the amount and nature of the restraint. If the parts being welded are free to move, the distortion is a maximum; if they are unduly restrained in order to prevent distortion, the locked-up stresses may be increased to an extent which may prove serious. Under bi-axial stress, even in a ductile steel, normal elongation is hindered and under tri-axial stresses, which may occur in heavy plating, any deformation is extremely unlikely. It is under these multi-axial stress conditions that the material is most likely to fracture in a brittle manner with slight deformation.

That cracks have developed in the plating of our welded ships during construction is generally known and while such occurrences have been rare they are naturally and properly cause for concern as evidence of the magnitude of the stresses that can be locked up in a welded structure. There are in general three main causes for such defects: (1) The unsuitability of the parent material for a welding technique which does not include preheating or stress-relieving due to high carbon segregation with consequent lack of ductility, (2) the use of a wrong welding sequence and (3) welding under cold weather conditions, especially if the temperature has dropped suddenly after welding; i.e., accelerated rate of cooling. It is difficult with our present knowledge to place the above causes in the order of their relative importance but if all three conditions exist simultaneously one need not look any further for the cause of the trouble. The facts with regard to (1) and (3) are easily established but it is not always so easy to determine just how and in what order the welding in the vicinity of the failure was carried out, especially where there is that division of responsibility among the supervisors incidental to the working of three shifts and where the night shift invariably gets the blame. It is perhaps too much to expect a welder to admit that he has deliberately departed from a carefully prepared sequence to which he was instructed to adhere rigidly. Our surveyors have explicit instructions to report the occurrence of cracked welds and plates and it is rather remarkable and perhaps significant that no case has been reported from any of the yards during the summer.

Actual Service Tests

While there are certain important advantages inherent in welded construction such as reduced weight and superior tightness which can be obtained apparently without any increase in initial costs, it is somewhat early to

claim definite all-around superiority over the riveted ship until such times as our all-welded ships have been subjected to the acid test of service conditions. However, an analysis of survey reports of damage resulting from collision, grounding, etc., would go to show that the welded ship is doing very well indeed. Some of these welded ships have recently been drydocked on account of some minor casualty and, while both plating and framing were found buckled in way of the damage, there was no evidence of any leakage and no immediate repairs were necessary, fortunately so in view of the present emergency conditions; a riveted ship which has suffered a similar casualty would very probably have had to be held in drydock for the carrying out of at least temporary repairs. The nature and extent of damage sustained as a result of enemy action are usually such as to render any real comparison between the riveted and welded ship a matter of some difficulty, especially where one is limited to written reports. The present restrictions on the taking of photographs places the responsibility on the proper authorities for taking steps to ensure that complete pictorial records and other relevant information with respect to such damages will be available after the war, as data of this kind will be invaluable in the interests of future progress in the structural design of welded ships.

Research

While the need for absolute concentration on the war effort in the interests of maximum production has naturally had the effect of slowing up welding research, there is a considerable amount of investigation being carried out under the auspices of the Welding Research Committee of the Engineering Foundation, which is sponsored by the AMERICAN WELDING SOCIETY. For example, work is now under way at three of our universities on a program of research which it is hoped will definitely establish optimum welding procedures and the welding conditions, including plate temperatures, which will ensure freedom from cracking in the welds and in the heat-affected zone of the base metal. This particular program will be of direct value and benefit to the shipbuilding industry and is being financed in part both by the Maritime Commission and the American Bureau of Shipping.

Conclusion

Ship welding has now gathered such a momentum that its continual progress can be confidently anticipated. Riveted construction for most classes of merchant ships appears to be definitely on the way out so far as our United States shipyards are concerned. Welding is already universal practice in the smaller type vessels, say under 300 ft. long, and is being rapidly extended to include the larger ocean-going vessels, a large percentage of such vessels building today being all-welded. In normal times, when it is a question of the survival of the fittest under stress of competition, the all-welded ship should be able to hold her own except perhaps in the case of the very large ship where it may be cheaper to continue to rivet rather than weld the heavy plating of shell and strength decks and where there is a practical economic limit to the size and weight of sub-assemblies, which cannot be increased indefinitely. Whatever the future may have in store for ship welding, there is no doubt but that the use of welding in ship construction has tremendously accelerated the war effort and has contributed enormously to that wonderful record of ship production of which our shipbuilders and the nation may be justly proud.

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Improved Methods of Machine Flame-Cutting*

By H. E. Rockefeller†

MECHANIZED oxyacetylene cutting has become a vital and indispensable means for the sizing and shaping of steel plate used in the production of war equipment. The cutting machine has taken its place in the production line today much as the manual cutting torch did as an accessory tool in the first World War.

One of the most important production uses of mechanized oxyacetylene cutting today is the shaping and edge preparation of steel plates, particularly for various types of combat vehicles where a large variety of multifaced edge contours has been specified. Tolerances in edge contours and over-all edge dimensions are closer now than specified previously for oxyacetylene cutting. In a number of shops, the tolerances that are being obtained closely approach, if not equal, those that are accepted in ordinary machine-tool practice. Typical multifaced edge-contour preparations that are specified for combat-vehicle armor plates are illustrated in Fig. 1.

These edges are being produced in some shops with the long-established and conventional tractor-type straight-line and templet-following, contour shape-cutting machines. These machines, equipped with standard-type blowpipes, are, however, limited to the cutting of a single edge face at a time. Furthermore, the accuracy in beveling is dependent upon the dexterity of the cutting operator in properly setting the bevel angle, in manually adjusting the blowpipe height to compensate for variations in the flatness of the plate and in aligning the portable tractor-type machine, which is normally set up on the plate, to the layout line of cut.

* Paper presented before the 23rd Annual Meeting, A. W. S., Cleveland, Ohio, October 13, 1942.
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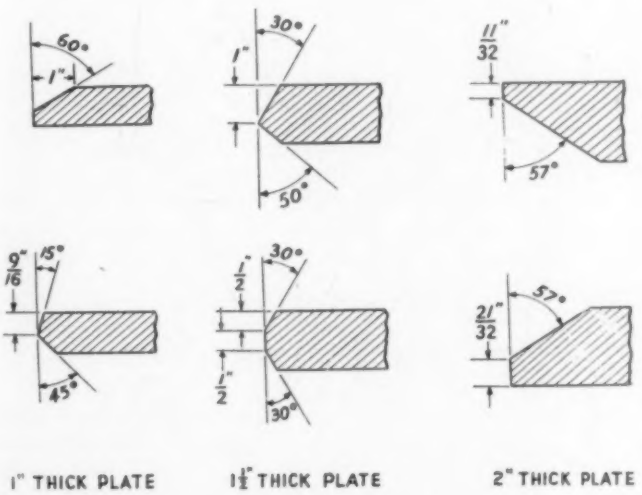


Fig. 1—Typical Edge Contours

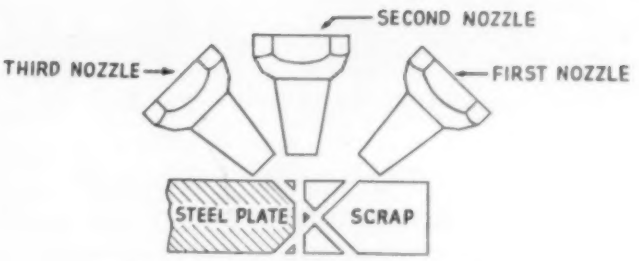


Fig. 2—Cutting-Nozzle Arrangement

The Development of Multiface Cutting

An outstanding advance in overcoming the above-mentioned limitations has been made through the application of a recently developed and improved method that we have termed "multiface cutting." This method involves the use of a series of cutting nozzles incorporated in a suitably arranged cluster and so located that any required edge contour can be cut with a single passage of the cutting equipment. An illustration of this preparation method for producing a double bevel with nose is shown in Fig. 2. The first nozzle produces the under-beveled surface, the second nozzle, the land or nose surface, and the third nozzle, the top beveled surface.

To insure the continuous production of a uniform edge contour, it is essential that the nozzles be maintained at a fixed distance above the work, and, since a plate being cut is rarely flat, the nozzles and appended gas-feeding equipment must be floated on the work. A setup that was developed several years ago for accomplishing multifaced cutting is illustrated in Fig. 3. It will be noted that a double parallel linkage was employed for floating the oxyacetylene equipment, and that individual blowpipes were used to feed the gases to the different nozzles. This equipment, while still in commercial use, has been superseded by the device illustrated in Fig. 4.

In this device, the nozzles are supported in a block or fixture that determines their location and angle setting. This fixture, which is replaceable for different individual edge-contour requirements, is attached to a vertical spindle, at the bottom of which is incorporated a plate-riding wheel. The spindle is enclosed in a sleeve at the top and bottom of which are four spring-loaded rollers. This construction permits free vertical motion of the spindle without wobble or side play, and the spring-loaded rollers automatically take up any wear or other possible effect due to expansion or contraction. The preheat gases are fed to a mixer and then distributed through tubes to the individual cutting nozzles. The cutting oxygen, likewise, is fed to a distributing manifold and thence through tubes to the separate nozzles.

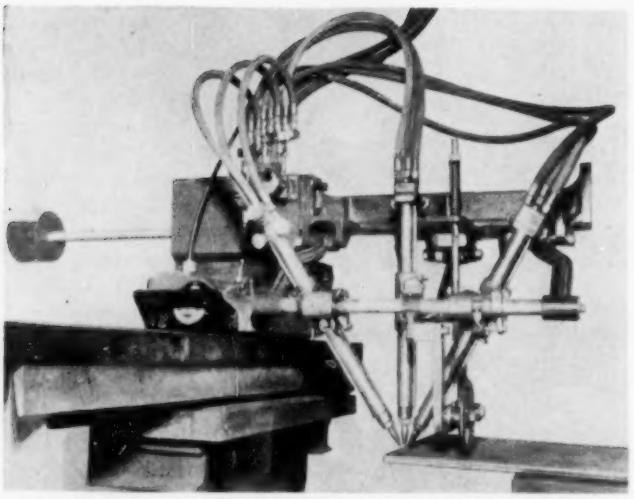


Fig. 3—Double-Linkage Type of Device for Plate-Edge Preparation

Use of the Fully Adjustable Nozzle Block

While the so-called fixed block shown in this illustration is satisfactory where a small number of edge contours are to be produced, it has been supplemented by a so-called fully adjustable block for applications requiring a large number of different edge contours. The fully adjustable block is illustrated in Fig. 5. This block consists of a body casting that includes a vertically disposed socket for the square cutting nozzle head and nozzle, and two horizontally disposed sockets into which are set the adjustable bevel-nozzle holders. These holders as illustrated are made up in two parts, the nozzle holder proper and the extension bar. As can be seen, the nozzle holder can be adjusted to any desired angle and can be spaced laterally and longitudinally in reference to the squaring nozzle as desired. The nozzle heads into which the nozzles are inserted are in turn inserted in the nozzle holders. With this fully adjustable block, any beveling combination involving three faces can be obtained.

Figure 6 illustrates the use of the fully adjustable block in producing a typical plate-edge preparation for which a double bevel with nose is specified. With the nozzles once correctly located in the fixture and carried at a uniform height above the work by the riding device,

Fig. 5—The Fully Adjustable Nozzle Block

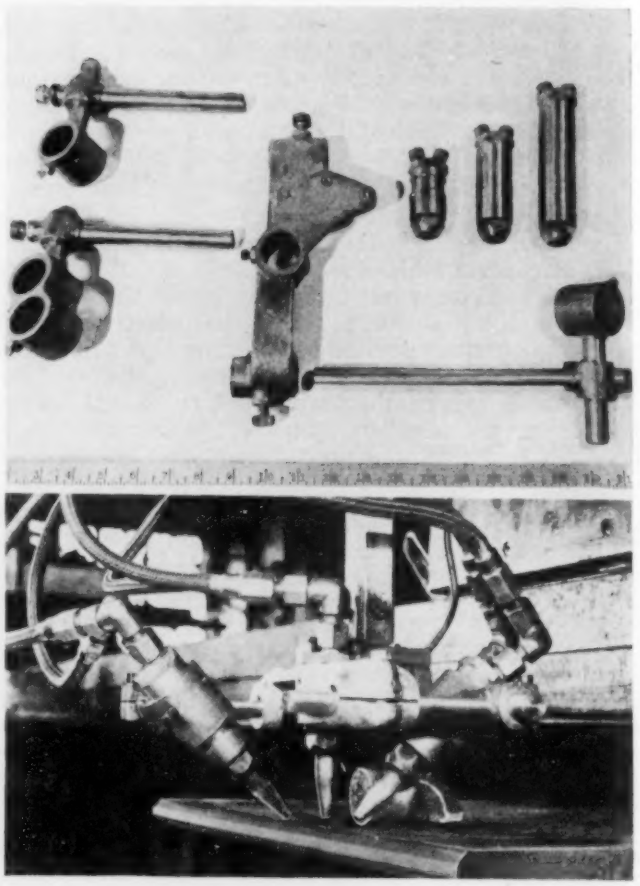


Fig. 6—Fully Adjustable Block Setup

a uniform and constant edge contour can be assured. The longitudinal spacing between nozzles is determined, furthermore, so that the combined heat generated permits a somewhat increased cutting speed over that which would be obtained if a single nozzle was employed. Irrespective of the increased cutting speed and the greatly reduced required setting-up time, an edge of this contour would be produced by this method in at least one-third the time required for the single-blowpipe, multipass method.

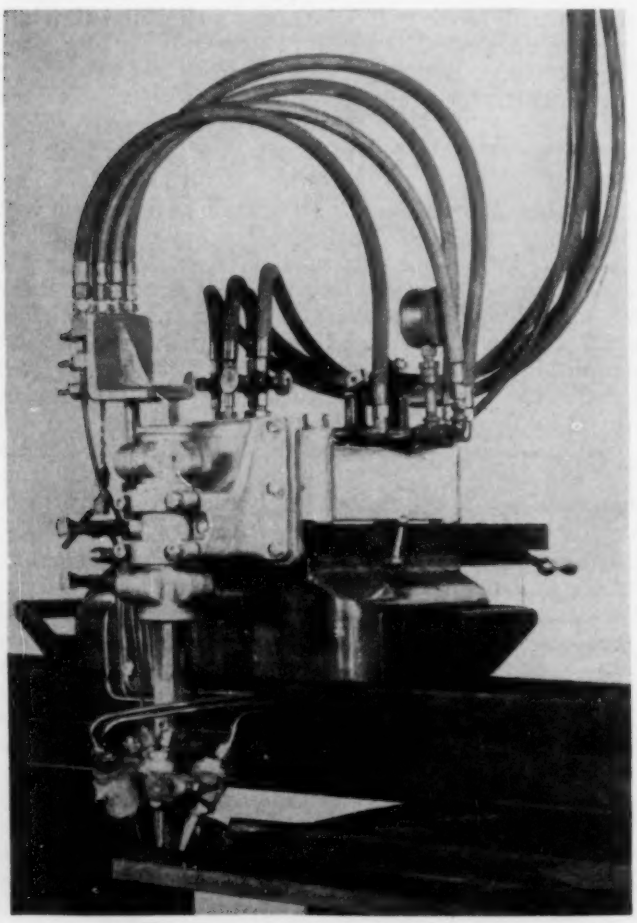


Fig. 4—New Type Setup for Plate-Edge Preparation

Use of the Auxiliary Cutting Jet

Where specifications call for bevel angles greater than 45°, it is difficult to obtain uniform results either in single-face or multiface cutting with the usual nozzle setup. This difficulty is due to the insufficient effective preheat that can be obtained from a single cutting nozzle.

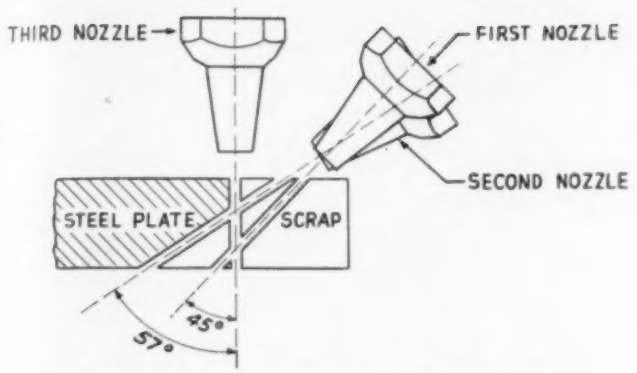


Fig. 7—Arrangement of Nozzles for Under-Beveling

In single-face cutting, supplementary preheat provided by a separate nozzle has been employed. In multiface cutting, however, it has been found that improved results can be obtained by the use of an auxiliary cutting jet.

The location of the nozzles for making a 57° underbevel with nose preparation is illustrated in Fig. 7. It will be noted that the leading or auxiliary nozzle is set at 45°. This cut heats the surface so that there is no difficulty in carrying the shallower bevel with the succeeding cut. The heated fin thus produced between the two cutting jets, furthermore, offers no obstacle to penetration by the jet from the vertical or squaring nozzle. Without this heated fin there is a tendency for the slag produced in making the squaring cut to deflect along the previously produced bevel and thus mar its surface. Figure 8 illustrates the setup and resulting edge produced in the application of the auxiliary-jet edge-cutting principle in preparation of a 57° underbevel with nose on 2-in. thick plate.

Savings by Multiface Cutting

For combat vehicles, plates are often furnished large enough so that a number of finished pieces can be produced from a single blank. Where the conventional tractor type of machine is employed, the plate is first cut into a series of rectangles, and the individual pieces are then beveled, one edge and one face at a time. This method of cutting not only is time-consuming but makes it difficult to obtain uniform and accurate results. It is difficult to maintain uniform bevels, and by cutting one edge and one face at a time, particularly on narrow plates, there is a definite tendency toward distortion of the plate during cutting.

Fig. 8—Setup for Under-Beveling with Nose

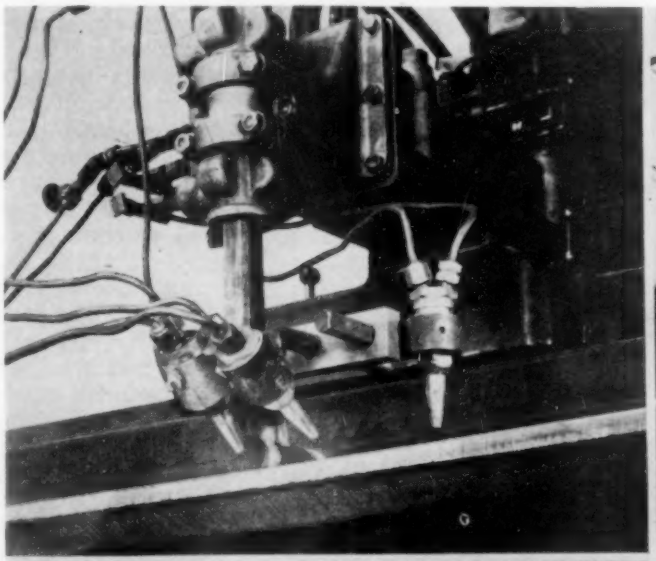
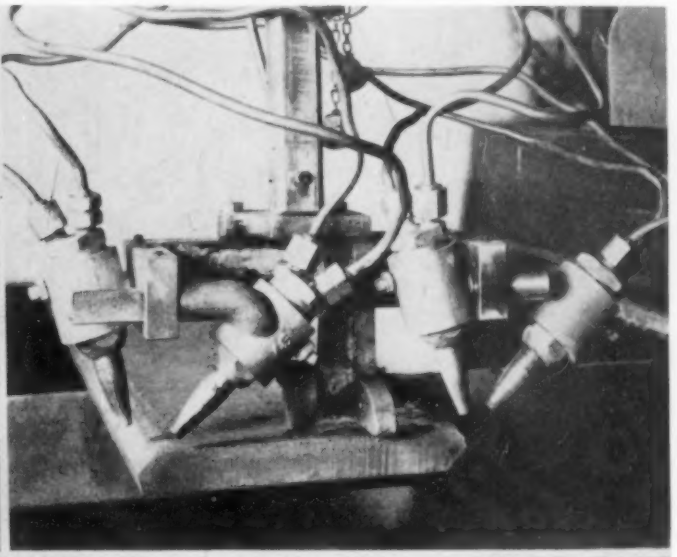


Fig. 9—Double-Beveling Adjacent Edges



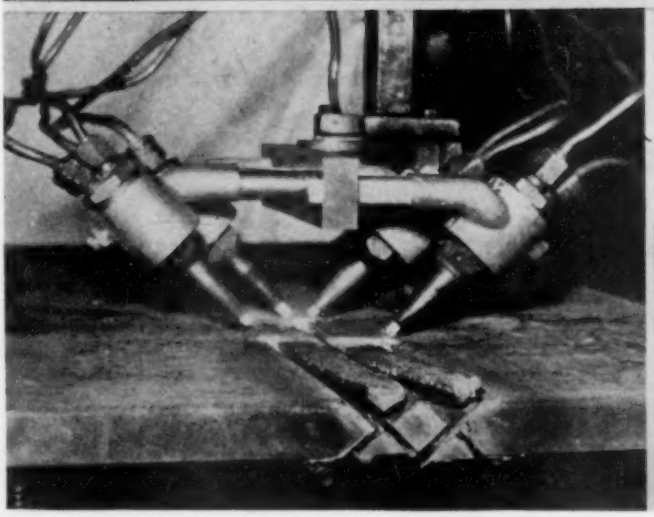


Fig. 10—Double-Beveling Adjoining Edges

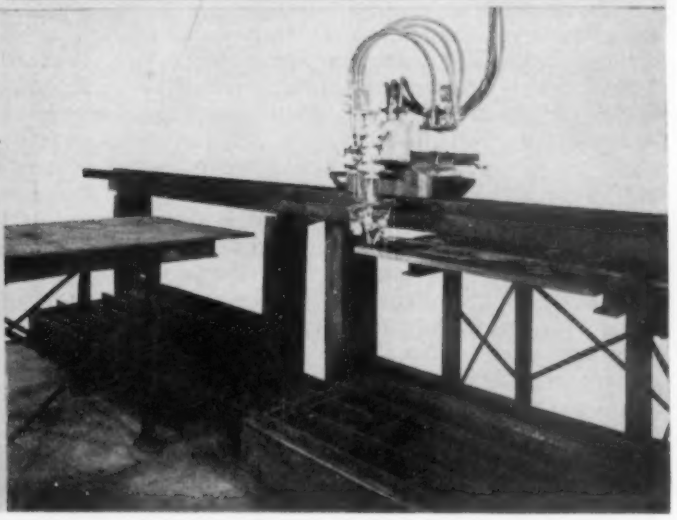


Fig. 11—Stationary Setup Using Tractor-Type Machine

In the application of multiface cutting, however, special fixtures have been developed for cutting plates of this type which makes it possible not only to produce one plate-edge contour in one pass of the equipment, but also to apply simultaneously the preparation to the adjacent edge. A setup for accomplishing the required preparation on a plate $7^{7}/_{16}$ in. wide by 63 in. long by 1 in. thick is illustrated in Fig. 9. By moving the equipment lengthwise on the plate, and making successive passes with the nozzle cluster, it is possible to produce a number of finished pieces in a small fraction of the time that would be required to accomplish the preparation by the common method. Constant and uniform results are obtained and distortion is avoided, because of simultaneous cutting on opposite edges.

Where the distance between cuts is such as to make the adjacent-edge type of block impracticable for application, it is possible to produce adjoining-edge preparations simultaneously, as illustrated in Fig. 10. As in the previous illustration, four nozzles are employed to produce the two required contours. A single pass of the cutting equipment in this instance accomplishes a result that would require five separate passes with conventional equipment, since the plate would first have to be cut square and separated before the individual bevel-angle faces could be cut.

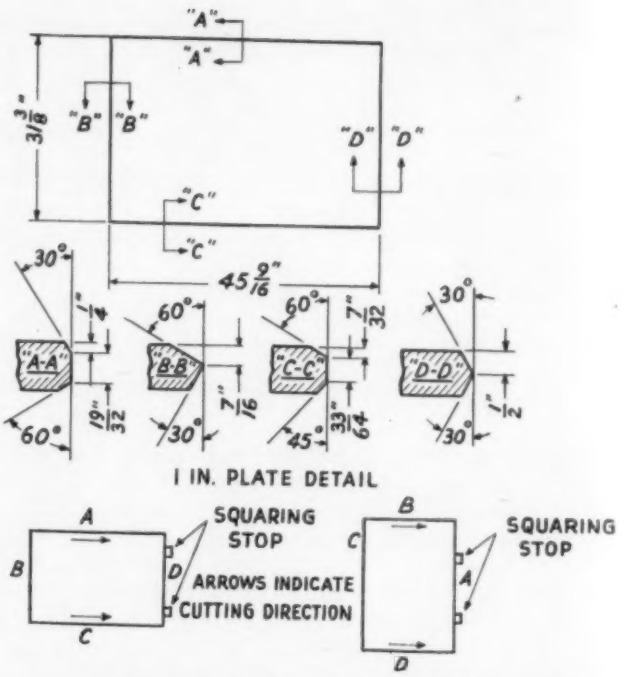


Fig. 13—Typical Work Sheet (Cutting with One Carriage)

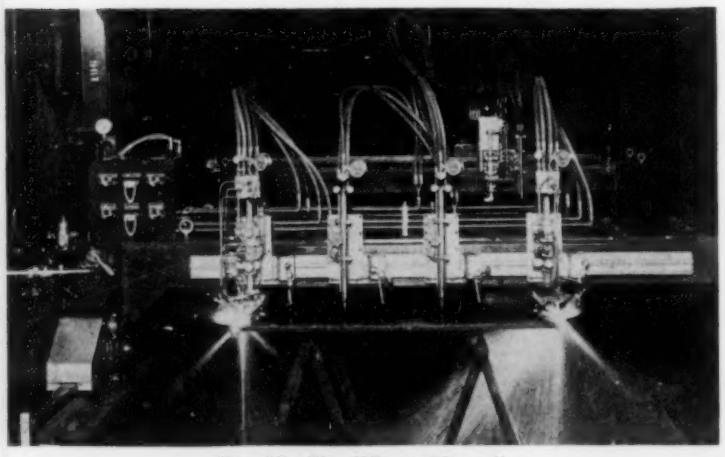


Fig. 12—The "Flame-Planer"

Two Types of Propulsion Units

In the application of multiface cutting, two types of propulsion units are being employed, a heavy-duty tractor-type machine and a recently developed bridge-carrier type of machine that we have named the "flame-planer." The tractor-type machine with equipment attached is illustrated in Fig. 11. With this equipment the track is located in a stationary position and the plate is brought to it and lined up so that the edge to be cut is parallel with the track. A number of units can be installed in much the same manner as is done with plate shears, the plate being fed to the various cutting positions by roller or caster conveyors. Where a large number of plates of the same detail are to be fabricated, track setups can be made to accommodate this particular shape, and a plate can be completely prepared without subsequent movement after its initial placement within the cutting area. This latter setup is particularly adaptable to the cutting of trapezoidal shapes. Sometimes, flexibility can be introduced by pivoting the tracks so as to provide means for obtaining different shape combinations.

For the production of large quantities of various sizes of plates that are wholly, or for the most part, rectilinear in shape, the "flame-planer" provides by far the most efficient unit for propelling the equipment for plate-edge preparation. A unit of this type is illustrated in Fig. 12. This unit, as can be seen, consists essentially of a bridge-type carriage driven on rails spaced apart a sufficient distance to accommodate the widest plate to be cut. The unit illustrated has a center-to-center rail distance of 10 ft. although similar units have been built with a rail span of up to 16 ft. The unit is propelled and the speed is accurately controlled by a motor and governor of the same type as is used in other oxy-acetylene cutting machines. Specially constructed guide rollers operating on a V-rail insure a straightness of longitudinal travel equivalent to that obtained on a machine-tool planer. As shown in the photograph, two plate-edge attachments and two standard cutting blowpipes are mounted on the carriage. However, it is possible to mount as many plate-edge units as are desired to meet the requirements for cutting. These units are mounted on base plates that are adjustable on a rack so that the units can be accurately spaced for cutting to the width or widths desired.

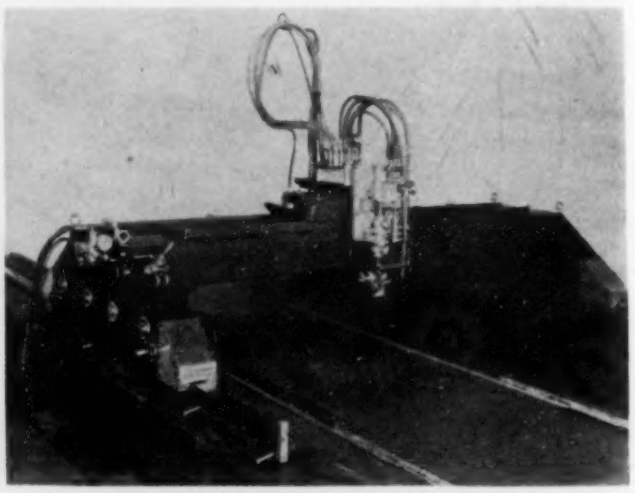


Fig. 14—Transverse Cutting Carriage

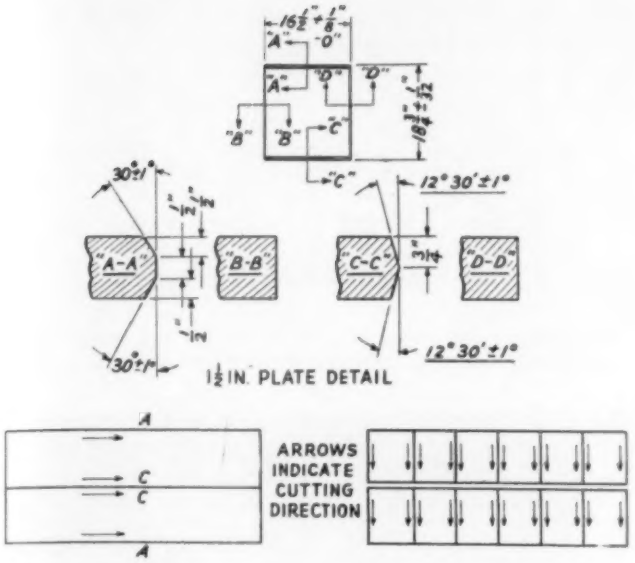


Fig. 15—Typical Work Sheet (Cutting with Two Carriages)

Use of the Flame-Planer

The cutting fabricator of armor plate for combat vehicles will often receive the plate pieces from the heat-treater in the so-called cookie size. In this size, there is usually only one finished piece to be obtained from the plate. Both dimensions of most of the rectangular plates to be cut are smaller than the maximum width that can be cut on the "flame-planer." For such plates, the machine illustrated can be efficiently employed by setting up two of the cutting attachments for preparing two opposite edges of the plate, and setting up the other two units for the other two remaining edges. A production layout sheet for a typical plate that has been cut in this manner is illustrated in Fig. 13. The production rate of cutting, with this layout, is tabulated in Table 1.

A number of single-piece cookies are laid on the work supports and the machine is operated with two cutting devices to cut two sides of each plate simultaneously.

Table 1—Production Rate (Cutting with One Carriage)

	Linear Travel, In.	Cutting Time, Min.
1st Operation	50	5.0
2nd Operation	35	3.5
Total	85	8.5
	Handling time	6.5
	Total time (actual)	15.0 min. per piece 25 hr. per 100 pieces

As soon as the carriage passes from one plate to the next, the cut plate is turned 90° from its original position, one of the edges being placed against squaring stops. After the carriage has been run the length of the cutting table, it is returned to the starting position and the newly aligned edges are cut simultaneously with the other two previously arranged cutting attachments. With this procedure, exceedingly close tolerances and high rates of production are obtained.

If the work is furnished to the cutting unit in a size that permits the cutting of a number of finished pieces from a single plate, the most efficient machine arrangement consists of a cross-cutting carriage in combination with the motivated carriage previously described. Figure 14 illustrates the cross-cutting machine. This bridge-type carriage is moved along the rails to the required cutting position and the transverse cutting is accomplished by a plate-edge device attached to a heavy-duty tractor which, in turn, operates on rails mounted on the carriage bridge.

Through the use of the "flame-planer" combination a number of rectangular pieces can be finish-cut from a large plate without movement of the plate after its original setting on the cutting bed. A typical production layout sheet for such a plate is illustrated in Fig. 15, with the production rate tabulated in Table 2.

It will be noted in this example that 12 finished pieces are cut from a single blank; three cutting devices are employed on the motivated gantry, the middle unit simultaneously preparing the adjoining edges of two

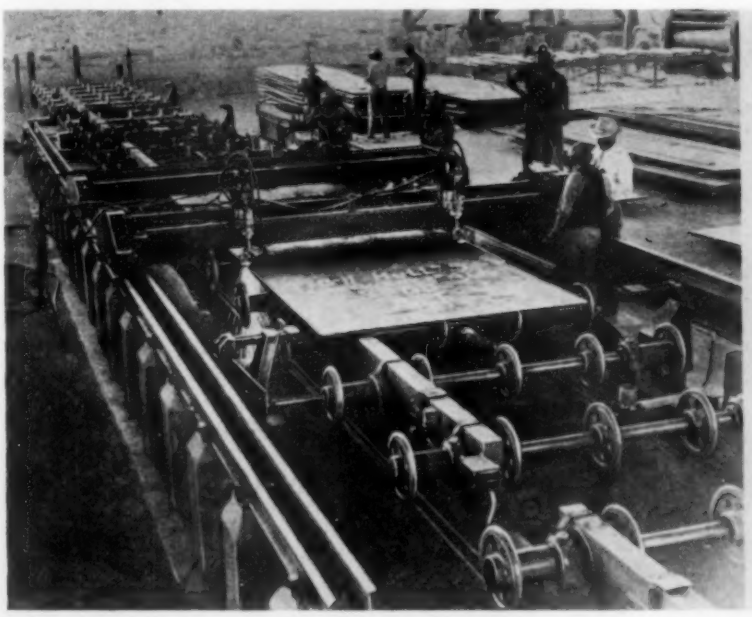


Fig. 16—Shipyard-Type Flame-Planer

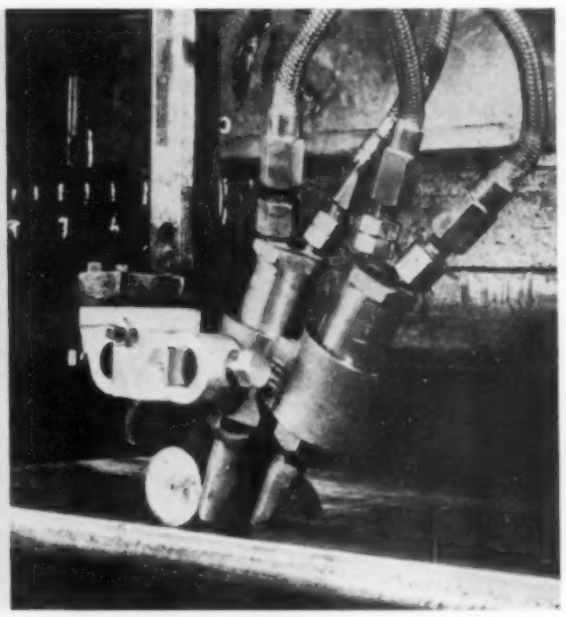


Fig. 17—The "Rip-Trim" Nozzle Arrangement

Table 2—Production Rate (Cutting with Two Carriages)

	Linear Travel, In.	Cutting Time, Min.
1st Operation	112	14
2nd Operation	264	33
Total	376	47
	Handling time	43
	Total time (actual)	90 min. per 12 pieces 12½ hr. per 100 pieces

plates. After the three cuts have been made with the motivated gantry to divide the blank into two pieces, the transverse cutting machine is employed, without movement of the pieces, to make the required crosscuts. In this way, 12 finished pieces are produced.

The two-gantry combination has been used effectively in shipyards for square-edge and bevel preparation of relatively large plates. A typical shipyard installation is illustrated in Fig. 16. As illustrated, only one cross-cutting gantry is shown, but the normal setup includes a cross-cutting gantry on either side of the motivated one. A number of installations of this type have been made, wherein a series of live conveyor rolls divided into receiving, cutting and discharge sections are employed. In the cutting section, manipulators for positioning and lining up the plates for the cutting operations are provided. Once the plate is placed by the crane on the receiving section, the entire operation of plate handling is semi-automatic and under the control of the operator at all times.

Use of the Rip and Trim Method

On a number of the lighter plates used in welded ship construction, the required edge preparation for Unionmelt welding is a square edge. To provide this edge preparation, a recent development known as the "rip and trim" method has been introduced. The "rip and trim" nozzle arrangement is illustrated in Fig. 17. As illustrated, two nozzles are employed in place of the conventional single nozzle used for square cutting. The first nozzle, as the term implies, rips the steel as is done in rough-machining. The trimming nozzle smooths the rough surface previously produced, resulting in a finished edge that compares with the highest quality obtained in single-nozzle cutting.

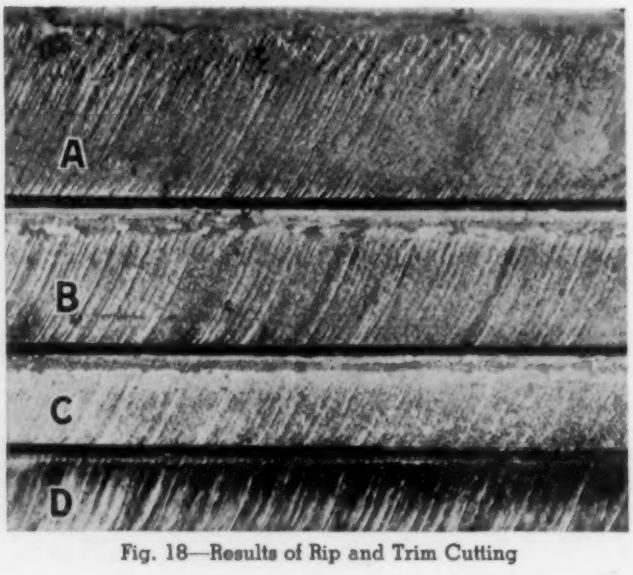


Fig. 18—Results of Rip and Trim Cutting

Typical results obtained with the "rip and trim" method are illustrated in Fig. 18. Speeds as high as 70 in. per minute on $^1/_4$-in. plate and 40 in. on $^3/_4$-in. plate are being obtained in some shipyards. These are the lightest and heaviest plates cut with square edge contour.

Use of Bevel-Cutting Attachment

For plates involving simple beveling or a considerable number of changes in direction of cutting, or both, to complete the piece a shape-cutting machine employing a templet formed to the plate shape can be used effectively. It was primarily designed for square-edge cutting with standard blowpipes It is limited, however, in beveling, even for single-face cutting, since the nozzle-to-templet distance will vary for different angles of bevel, and, where different bevel angles are used in a single piece, a continuous templet cannot be employed. This limitation is beveling with shape-cutting machines has been overcome by the development of a bevel-cutting attachment, which is illustrated in Fig. 19. The principal feature of this device provides for rotation of the blowpipe nozzle about a fixed point in the plate so that the cutting stream impinges at this point irrespective of the bevel angle being produced. The device, further-

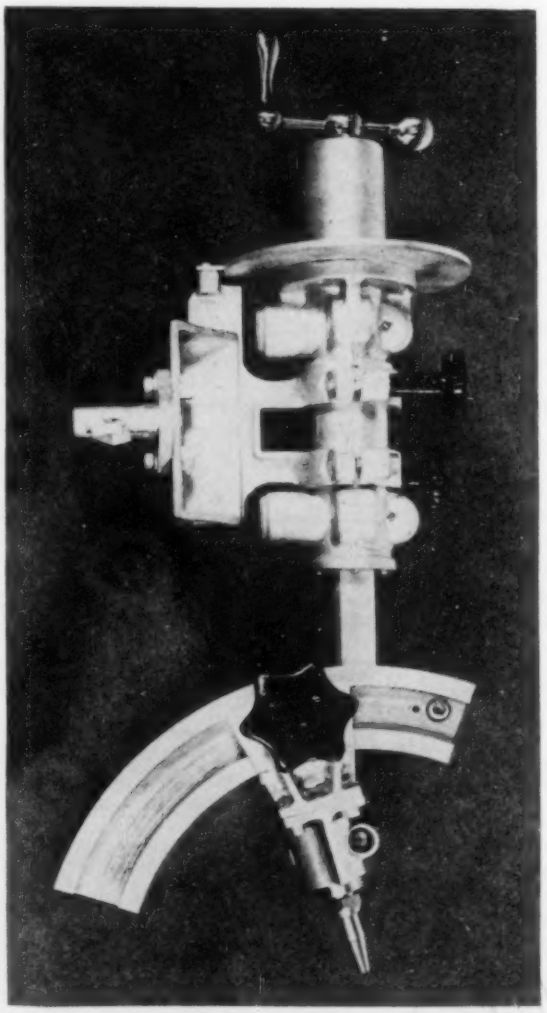


Fig. 19—Bevel-Cutting Attachment for Shape-Cutting Machine

more, rotates about a center point so that the point of impingement is not affected by the direction of cutting. Other features of the design include a segment for readily and accurately setting the bevel angle, a spring-loaded vertical slide which assures maintenance of the desired setting as the unit is raised or lowered to compensate manually for undulations in the plate, and an angle selector for easily rotating and setting the device to the desired line of travel. This device has materially aided in the production of bevel cuts where a shape-cutting machine can be efficiently employed to supplement multiface cutting.

The demands for the production of war materials from steel plate have and are continuing to stimulate developments in improved cutting machines and accessories and in more efficient cutting practices. Multiface cutting will, it is believed, contribute largely in these developments for plate-edge preparation not only through greatly increased production, but in obtaining greater accuracy and uniformity in the resultant pieces produced.

The Redesigned 40-Mm. Anti-Aircraft Gun Carriage*

By Dr. John L. Miller†

DURING February 1941, the Firestone Tire and Rubber Company was approached by the commanding officer of the Cleveland Ordnance District, with a request that this company consider the redesign and manufacture of a 40-mm. anti-aircraft gun carriage. This gun carriage was to be made over the lines of the Swedish Befors Automatic Anti-Aircraft Cannon. Prior to the time of the request, the Army Ordnance Department had made a complete survey of the manufacturing facilities of plants throughout the United States, and at that time, the use of our company's facilities for the manufacture of defense materiel was volunteered. The survey had shown the company to have available a large machine shop, well equipped with modern machine tools and skilled personnel. This machine shop had been engaged in the manufacture of various types of molds, dies and machinery, designed and developed by the organization for its plants located throughout the world. Its existence was a deciding factor in the selection of a rubber company for the production of an anti-aircraft carriage.

The civil war in Spain had demonstrated the value of an intermediate caliber, automatic cannon for defense of vital supply centers and for defense of field troops against operations of low-flying aircraft. During that period, the 40-mm. Befors gun proved its efficiency and reliability. Since then this gun has been widely adopted, particularly by the British and now by the American forces. The decision was based on reports from, and personal observations in, combatant countries and as a result of exhaustive tests of pilot models at the Aberdeen Proving Grounds.

The 40-Mm. Anti-Aircraft Gun and Carriage

The 40-mm. anti-aircraft gun is mounted on a top carriage attached to a cross bed chassis having lateral outriggers. This chassis is mounted on four wheels equipped with 6.00 x 20 transport tires having bullet resisting tubes, all wheels having electric brakes. The carriage wheel base is 126 in. The gun may be elevated from $-5°$ to $+90°$ or through a $95°$ arc, and may be traversed $360°$. The projectile has a weight of approximately 2.2 lb. and leaves the muzzle at a velocity of 2850 ft. per second. Shots may be fired at the rate of 120–140 per minute, usually in bursts of 4–6 shells. In view of its rapid maneuverability, the gun is adapted particularly to use against low-flying aircraft, including dive bombers. It has a maximum horizontal range of approximately 11,000 yd. and a maximum vertical range of approximately 5400 yd. The effective range is 2500 yd. horizontal or vertical. During firing, the gun carriage is supported at four points by jacks having large diameter foot plates and additionally secured by four stakes driven into the ground, guided by brackets attached to the chassis. The front and rear wheels are retracted during firing in order to eliminate vibration which would occur if the recoil energy were transmitted to the ground through the rubber tires. This retraction is accomplished by the equilibrating action of strong springs housed within the box girder of the chassis frame. The electrical wiring for the brakes, the front and rear lights and the wiring which conveys current to the motors which operate the oil gears, also are housed within this box girder. This is an additional advantage of the box type construction. Calculation and experience have shown that the box type of construction results in the strongest possible frame for a gun carriage of this type. The gun breech and tube are manufactured by another corporation and forwarded to our plant for assembly on the gun carriage. The total weight of the complete gun and gun carriage is approximately 6000 lb.

The Redesign Period

An imported mount was made available for our study. Such drawings as were furnished showed dimensions in the metric system and employed metric or first angle projections. It was required to transpose all these drawings to accord with United States Ordnance Standards, this involving the redrawing, and in many instances the redesigning, of approximately 1400 separate drawings and the introduction of 460 United States Government standard data sheets for parts such as nuts, bolts, screws and washers. Another extremely important transposition involved changes of all materials used in fabrication so as to make them available within the United States.

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* Second Grand Award ($11,200) paper in the 1940–42 Industrial Progress Award Program sponsored by The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio. The award papers showed a possible saving of $1,825,000,000, including 7,000,000 tons of steel and 153,000,000 man-hours of labor available by application of arc welding.

† Chief Metallurgist, Gun-Mount Division, The Firestone Tire and Rubber Company, Akron, Ohio.

A complicating restriction imposed was the necessity for selection of materials adequate for the intended service but containing a minimum of alloying elements which are particularly strategic. To illustrate this, the English had made a large number of parts using steel containing appreciable quantities of nickel. The material changes made almost completely eliminated nickel containing steels. In most cases these material changes were accomplished without reduction of the unit area physical properties by taking full advantage of processing and heat-treating methods proved by modern metallurgy. A total of 1485 individual parts are required for the gun carriage.

During this period, many design changes were proposed, and approved by the United States Ordnance Department. Important design changes which are saving millions of dollars in machine tools and in man-hours of labor are the employment of welded construction, the use of a single ball thrust bearing instead of a double constructed ball thrust bearing for the traversing gear, the elimination of thrust bearings in the elevating gears, the use of anti-friction bearings made from powdered and sintered metals instead of solid bronzes, a tubular welded axle construction instead of a forged axle, a change in the method of mounting the gun trunnions on the top carriage, the employment of rubber bumpers instead of a steel spring within the draft connector and the use of four-wheel electric brakes instead of two-wheel hydraulic brakes. Of these the most important change was the use of welded instead of riveted construction. The ordnance designers had suggested that we investigate the possibility of welded construction for the chassis and top carriage. Welded designs for these parts were developed by Firestone, assisted by subcontractor engineers, and the use of welding extended to include many other components. This redesign was all the more remarkable in that it had to be conducted simultaneously with the transformation from the metric to the American system and with the change from foreign to American materials, with a minimum of time lost in getting into production. The weldability of each material forming part of a welded assembly was carefully considered and chemical analyses controlled to give the best welding characteristics consistent with the designing engineers' strength requirements. To insure relief of local locked-up stresses occurring during welding and during cooling from welding temperatures, it was deemed advisable to stress relieve all important weldments. Therefore, the minimum design strength of each welded material was determined in terms of its room temperature strength after exposure to a temperature of 1150° F. for a minimum period of 1 hr. Welding engineers and metallurgists will be interested in studying the chemical analyses and physical property data to be given later for a complete appreciation of how this was accomplished. The extensive use of the new low-alloy, high-strength steels is noteworthy.

In order to meet the strength requirements of the Army Ordnance Department—these being much more rigid than those applied to foreign designs—the plates used in the construction of the entire gun carriage were made 50% thicker. As the drawings for the redesigned gun carriage were completed, they were immediately used for the construction of parts for two experimental models. By adopting such a procedure, it was possible to have these models ready very soon after the last of the drawings had been made. These pilot models were completed in June 1941, and sent to the Aberdeen Proving Grounds for testing. Gun breeches and tubes were obtained from a Canadian source and exhaustive roadability and firing tests conducted. These Aberdeen tests proved the general excellence of the redesigned welded carriage, although slight increases in the sectional thicknesses of a few parts subsequently were made, an additional strengthening member at the front of the carriage was added, and the draft connector was made longer and heavier. This redesigned and improved carriage is now able to travel at the highest speed of which the prime mover is capable, and, within 1 min., be placed in firing position with complete assurance that firing accuracy has not been impaired. This required firing accuracy is dependent as much upon the strength and precision built into the carriage as into the manufacture of the breech and the tube, because the elevating and traversing mechanisms form part of the carriage, and these must be manufactured to extremely close dimensional tolerances. Any lack of gun carriage rigidity during travel or during actual firing would be translated to these mechanisms, causing overstressing with consequent distortion. This carriage is, then, not only a means of conveyance for the gun, but an integral part of the operation of the gun itself.

Cost figures for the Bofors gun or for the English modification were not available. Because of different wage standards, such cost figures would have been of little value even if available. During the redesign period, detailed estimates of the expected costs of riveted and welded constructions were developed. These estimates indicated that a welded construction would save considerable money and labor, and the employment of welding jigs and fixtures made the welded construction more advantageous for quantity production, with a minimum of delay. The design of carriage details is not static and in a minor way is changing from day to day, simplifications being introduced which result in increased production at less cost. Whatever the design change may be, it is necessary that each important part or subassembly be made interchangeable with foreign models and with carriages produced during other stages of our manufacture. This is such an important consideration that many desired changes must be sacrificed.

Organization

In order to accelerate production on this contract, a separate group of buildings and a personnel distinct from that of the parent company were established. Executive, designing, purchasing, planning, materials, metallurgical, machining, assembling and accounting departments were formed. Close cooperation between each department was essential and each was placed as close to the other as space limitations permitted.

In view of the magnitude of the undertaking, the comparatively short time available in which to get this new undertaking into production, and the desire to make use of the facilities of companies adversely affected by the war industries program, a large number of firms were engaged to supply many of the subassemblies. Companies capable of producing certain of the subassemblies were asked to quote on a firm price basis. The capacity of each subcontractor to produce parts is closely weighed in terms of the number required to insure a constant flow so that continued assembly is not interrupted. Since initial contracts for some of the subassemblies were placed, it has been necessary, because of production requirements, to let other contracts for the same parts, and today as many as four different firms are fabricating the same subassembly. In view of this, actual costs of fabrication necessarily vary from plant to plant. Another factor complicating the establishment of exact cost figures is the continually accelerating program arising from the

Fig. 1—A Panoramic View of a Section of the Assembly Floor Showing a Number of Completed Gun Carriages, Ready for Installation of Gun Breech and Tube

national emergency. At the time when the first contract was signed, it was decided to establish production on a conservatively low basis. Since that time, the requirements for our company have steadily increased and now exceed by many times the original number.

Although the resources of a large number of subcontractors are being used, all drawings and material specifications and fabrication directions emanate from the prime contractor and for this reason all methods employed are essentially the same for identical parts. Facilities for the manufacture of this piece of Ordnance matériel are being tremendously expanded within our organization, but the requirements of the War Department for this effective piece of equipment have increased to such an extent that two additional prime contracts have been placed. Designs and drawings developed at Firestone are being used by these other two prime contractors.

To indicate the present magnitude of the production schedule, there is shown in Fig. 1 a view of a section of the assembly floor which contains a large number of carriages complete and ready for the mounting of the breech, gun barrel or tube and automatic control equipment. In Fig. 2 the gun is shown in firing position with the wheels retracted and the entire gun carriage supported and leveled by the four jacks.

Welded *vs.* Riveted Construction

The entire frame structures of the original Bofors guns and of the English adaptation of it were riveted. This included as major items the chassis, the top carriage and the elevating gear segment. Over 1000 rivets were required to complete these assemblies.

This discussion is devoted to the advantage of welded design in comparison with the riveted construction employed by foreign manufacturers. In view of the necessity for obtaining greater strength for better roadability, the American carriage is, therefore, necessarily heavier than the English or Bofors constructions. In order to

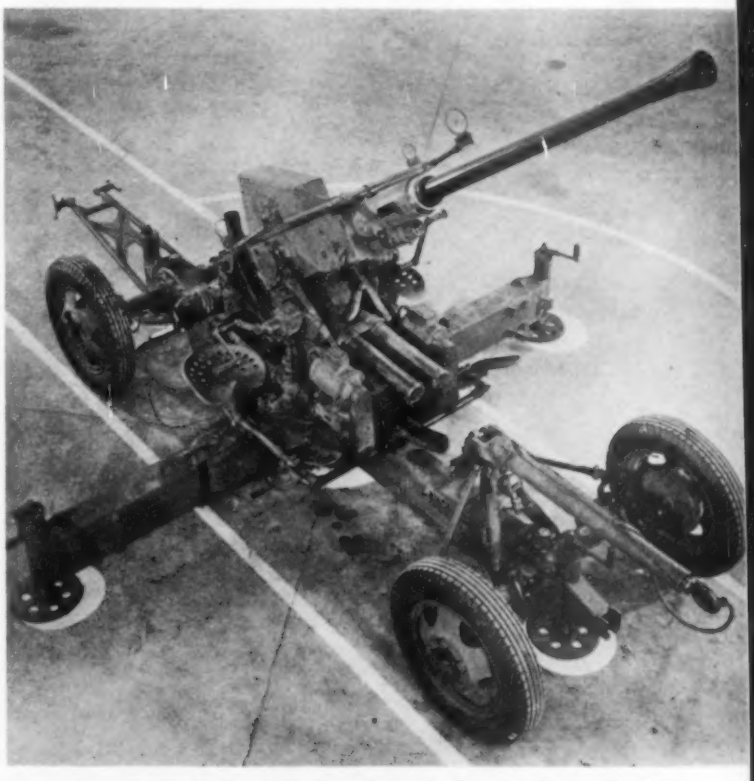


Fig. 2—A 40-Mm. M1 Anti-Aircraft Gun in Firing Position. This Gun Is at a Station Where it Is Being Tested for Firing Accuracy

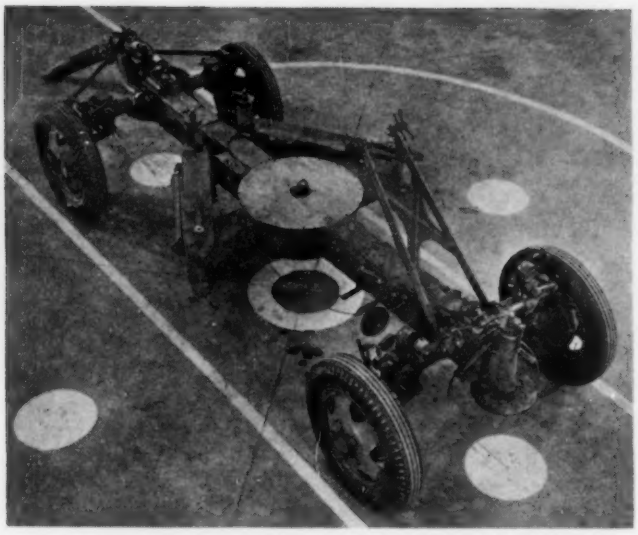


Fig. 3—A Close-up View of a Gun Carriage Ready for Mounting of the Top Carriage and Gearing Mechanisms

obtain a comparable picture of the weight advantages accruing as a result of the employment of welded rather than riveted construction, the data as presented will show the actual weight of the American model subassembly, the weight of the corresponding English riveted subassembly and, finally, what this weight would be if riveted construction were used and if the section thicknesses were the same as employed in the American model.

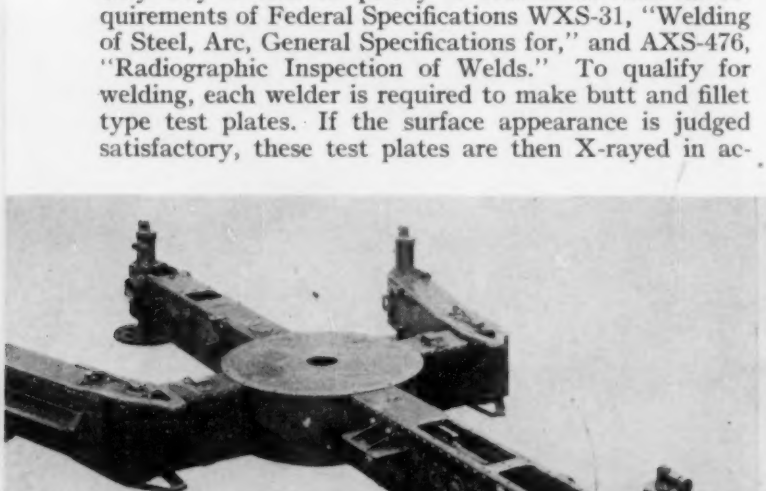
The Carriage Chassis

At present, three subcontractors are engaged in the manufacture of the chassis. Each contractor for each welded subassembly is required to train welders so that they may be able to qualify in accordance with the requirements of Federal Specifications WXS-31, "Welding of Steel, Arc, General Specifications for," and AXS-476, "Radiographic Inspection of Welds." To qualify for welding, each welder is required to make butt and fillet type test plates. If the surface appearance is judged satisfactory, these test plates are then X-rayed in accordance with government specification requirements and, if acceptable, the test plates are then stress relieved in a manner identical with the method employed in the treatment of the subassemblies on which the welder is expected to work. Three tensile test and three bend test specimens are then machined from the stress relieved plates and tested to determine if the weld metal satisfies the specification requirements for the materials being joined. These tests are conducted under the supervision of government inspectors of the Ordnance District in whose territory the welder is to work. At least one month of actual welding under the direction of a competent supervisor is required to train an inexperienced welder so that he is able to meet government specifications.

As indicated in Figs. 3 and 5, this chassis is of the box girder type, having two outriggers. The steel used in the chassis construction is of the low-alloy high-strength type, supplied under Federal Specification 57-114-1, Class B, Grade 2. This specification limits the chemical analysis to a maximum carbon content of 0.25%, leaving additions of other elements unrestricted. It imposes a physical property limitation of 50,000 psi. minimum yield strength, 95,000 psi. maximum tensile strength and 20% in 2 in. minimum elongation. The material actually used conforms to the following approximate chemical composition:

Table 1—Physical and Chemical Property Values—Experimental Plain Carbon Steel Welds on Low Alloy, High-Strength Steel

Yield Strength, Psi.	Tensile Strength, Psi.	Elongation % Free Bend Test	Average Chemical Analysis, %	
60,960	84,020	38.0	Carbon	0.15
59,590	79,540	56.0		
55,580	78,900	42.0	Manganese	0.53
58,160	77,790	46.0		
59,910	76,930	44.2	Silicon	0.43
54,440	80,100	54.0		
57,000	79,030	45.2	Chromium	0.31
57,440	78,860	48.0		
53,570	77,620	62.0	Nitrogen	0.015
59,050	77,850	39.5		



. 4—A Close-up View of the Riveted Chassis Sent from England as a Model Construction of the 40-Mm. M1 Anti-Aircraft Gun Carriage. Notice the Riveted Construction Used Throughout

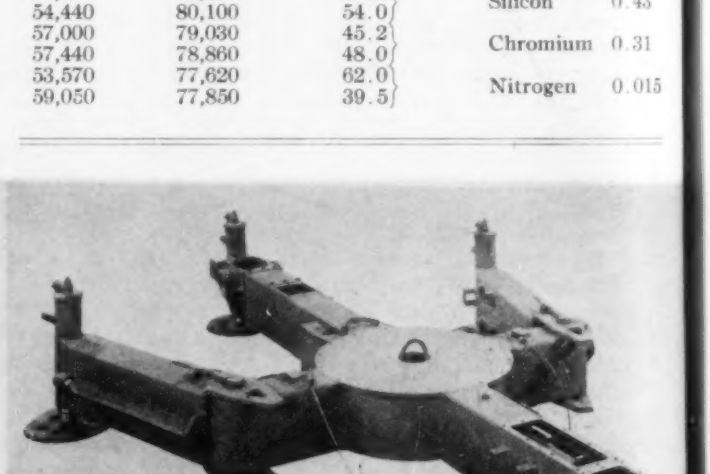


Fig. 5—A Close-up View of the Redesigned Chassis in Which Welded struction Has Been Employed. This Figure Should Be Compared with

—A Close-up View of the Tub or Central Section of the Riveted Carriage ...ted as a Model. Note That a Slight Amount of Welding Has Been Used

Fig. 7—A Close-up View of the Tub or Central Section of the Welded Ch...

Carbon	0.10–0.20%	Zirconium	0.10–0.20%
Manganese	0.50–0.70%	Sulphur	0.04% max.
Silicon	0.60–0.90%	Phosphorus	0.04% max.
Chromium	0.50–0.65%		

The plates forming the box sections are $^{3}/_{16}$ in. in thickness and the plates forming the tub or central section are $^{1}/_{2}$ in. and $^{3}/_{16}$ in. in thickness. All of the subassemblies are positioned for welding, the fixtures required usually being manufactured in the plants of the subcontractors. Plain carbon steel, covered electrodes, $^{5}/_{32}$ in. in diameter are used. Experiments had indicated that the use of an alloy electrode was not required to obtain strength equal or superior to the strength requirements for the rolled, forged or cast sections being joined. No special preparation of the joints is necessary and a low-carbon steel backing-up strip is employed. Sixty-six pounds of $^{5}/_{32}$ in. diameter electrodes are required for the complete welding of the chassis. In Table 1 are shown typical physical properties secured on experimental test plates, which had been stress relieved at a temperature of 1150° F. Included in this table is a typical weld metal chemical analysis as obtained from single bead welds made on $^{3}/_{16}$ in. thick butt welds.

Figure 4 is a photographic view of the riveted construction employed in the manufacture of the foreign models. Figure 5 illustrates the corresponding welded construction now being used. The welding methods used in attaching brackets, stake supports, outrigger locks and other parts to the chassis frame, should be compared with the procedure employed in fastening corresponding parts on the foreign model. Figures 6 and 7 contrast the designs employed in fabrication of the drum or central section of the chassis. Figures 8 and 9 contrast the designs employed in forming the bottom section of the drum or central section. The foreign design does not completely cover the bottom of the tub. Obviously this would be impossible because of the necessity for getting on the inside to rivet. It will be noted that a double plate is required to secure the needed strength. The welded design consists of a single plate which completely covers the tub bottom, thus adding needed strength without the necessity of having an additional plate. Figure 10 is a photograph of the construction employed at the front or swivel end of the foreign model. Aside from the riveted construction, a needlessly expensive method of securing the bearing surface for the axle tube was used. The redesigned model employs powdered and sintered metal anti-

Fig. 8—A Bottom View Showing the Riveted Construction Employed in Making the Tub or Central Section of the Foreign Model

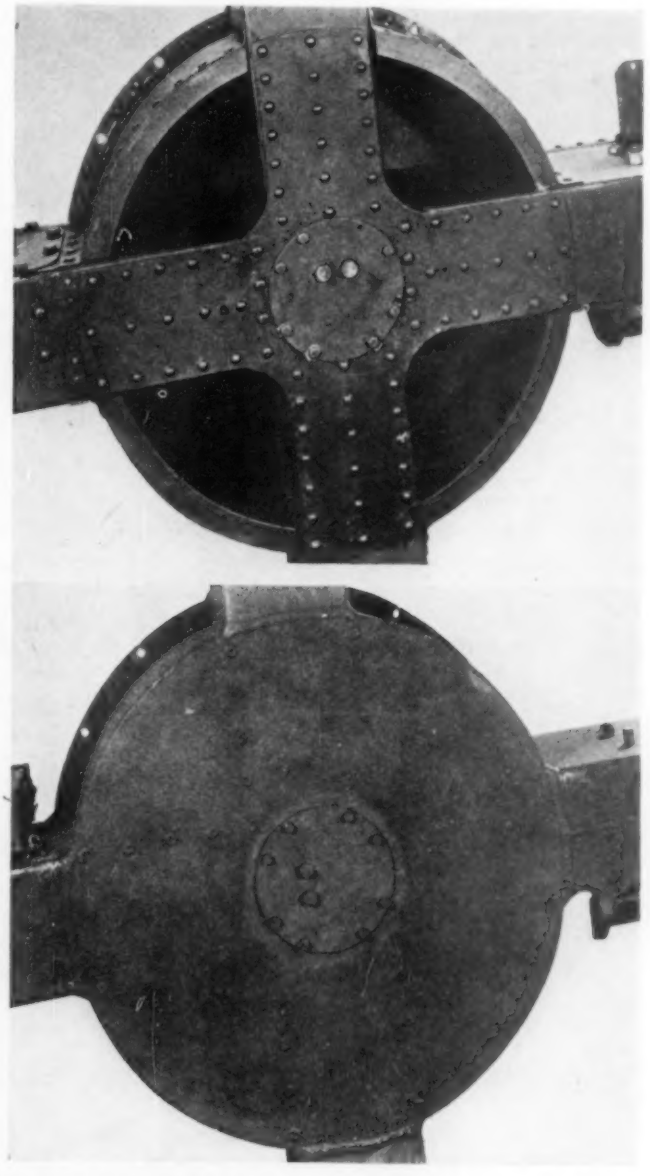


Fig. 9—A Bottom View Showing the Welded Construction Used in the Fabrication of the Welded Tub

Table 2A—Physical Properties of Parts Used in the Chassis

Part Name	Material	Yield Strength, Psi.	Tensile Strength, Psi.	Elongation in 2 In., %	Reductions of Area, %
Spline shaft	WD 1035	65,000	81,000	16	..
Eccentric sleeve	WD X4130	75,000	100,000	20	..
Plate top	Low-alloy, high-strength steel	50,000	95,000	20	..
Jack tube	WD 1020	53,000	64,000	23	..
Backing strip	WD X1020	40,000	60,000	20	40
Jack tube plate	WD X1020	40,000	60,000	20	40
Rib support	Low-alloy, high-strength steel	50,000	95,000	20	..
Side plates	Low-alloy, high-strength steel	50,000	95,000	20	..
Stake bracket guide	Steel casting	53,000	85,000	22	35
Eccentric boss	WD X1020	40,000	60,000	20	40
End plate	Low-alloy, high-strength steel	50,000	95,000	20	..
Eccentric bracket	Low-alloy, high-strength steel	50,000	95,000	20	..
Bottom plate	Low-alloy, high-strength steel	50,000	95,000	20	..
Cap reinforcing block	WD 1035	40,000	70,000	20	40
Stake tip	WD 1035	40,000	70,000	20	40

friction bearings for the axle tube. The redesigned front end is indicated in Figure 11. The simplified lines and the increased rigidity made possible by the use of arc welding is apparent.

Rigidity Tests

Exhaustive deflection tests to determine rigidity of the chassis in comparison with the imported model were made to check the redesign calculations and the unit strength of the metals and welds in the new chassis. One such test will be described.

Two chassis, one the English riveted model, and the other our welded chassis, were placed on a level concrete floor in a position as indicated in Fig. 3. Six dial indicators graduated in thousandths of an inch then were mounted on separate supports under the central or tub section and positioned in a circle at 60° intervals. A 3000-lb. weight, which was a static overload of 75%, was placed on top of the central or tub section and the deflection noted on each of the six dial indicators. This test was repeated several times with the following average results.

Riveted chassis—0.079-in. deflection
Welded chassis—0.051-in. deflection

The difference of 0.028 in. in favor of the welded chassis corresponds to 0.028/0.051 × 100 equals 55% greater strength for the welded chassis. Both chassis returned to their original positions when the loads were removed, indicating that the stress was completely elastic and that the load was not sufficient to produce plastic or permanent deformation. Other similar deflection tests on the front, rear, left and right ends gave corresponding results, all of which were later confirmed by road tests at the Aberdeen Proving Grounds.

The weight of the riveted chassis is 824 lb. and the weight of our welded chassis without the steering support is 1071 lb. The weight difference of 247 lb. combined with the welded design has produced this 55% strength increase. The increase in strength resulting

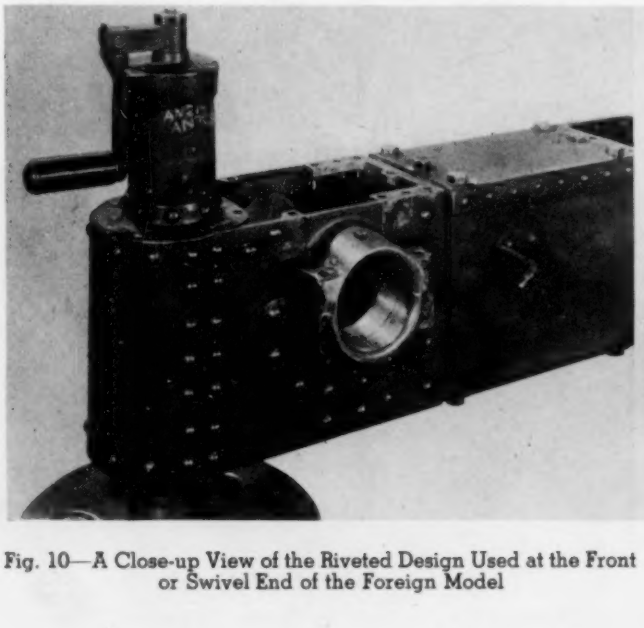


Fig. 10—A Close-up View of the Riveted Design Used at the Front or Swivel End of the Foreign Model

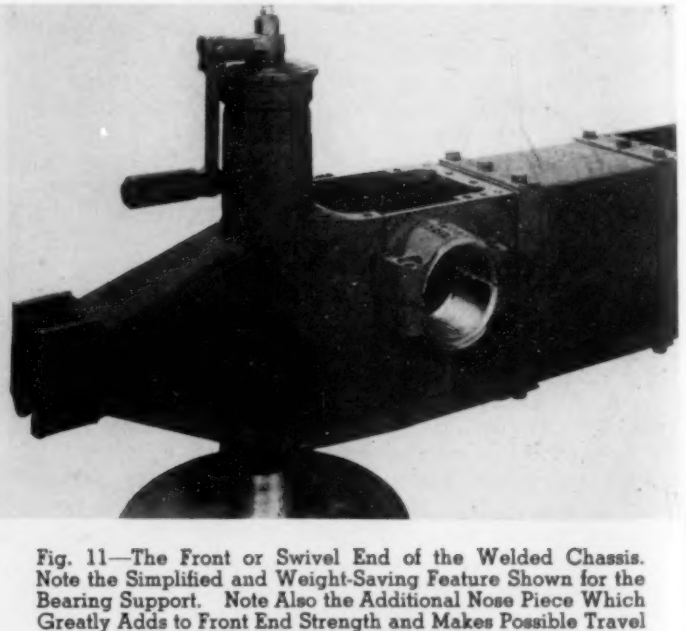


Fig. 11—The Front or Swivel End of the Welded Chassis. Note the Simplified and Weight-Saving Feature Shown for the Bearing Support. Note Also the Additional Nose Piece Which Greatly Adds to Front End Strength and Makes Possible Travel Over Much Rougher Roads

Table 2B—Chemical Analyses of Materials Used for Parts of Chassis

Material	C	Mn	P, Max.	S, Max.	Cr	Other Elements
WD 1035	0.30–0.40	0.60–0.90	0.045	0.055	.....	.....
WD X4130	0.25–0.35	0.40–0.60	0.040	0.050	0.80–1.10	Mo 0.15–0.25
Low-alloy, high-strength steel	0.10–0.20	0.50–0.70	0.040	0.040	0.50–0.65	Si 0.60–0.90 Zr 0.10–0.20
WD 1020	0.15–0.25	0.30–0.60	0.045	0.055	.....	.....
WD X1020	0.15–0.25	0.70–1.00	0.045	0.055	.....	.....
Steel casting	0.30 max.	1.10 max.	0.050	0.065	.....	Mo 0.40–0.65 Si 0.55 max.

from the use of welded construction is therefore 25%, calculated as follows:

1071 − 824 = 247 lb. additional weight

247/824 = 30% additional strength resulting from increase in amount of metal used

55% − 30% = 25% *additional strength resulting from the welded design*

This additional strength is due to the fact that the welded chassis functions as an integral unit under stress. The nosepiece, shown in Fig. 11, adds greatly to the strength of the front end of the carriage as it forms a rigid support for the steering mechanism. This addition, which greatly improves the road performance of the American redesigned model, is not present on the foreign model.

Materials Used

In order to insure weldability of all brackets, supports and locks which are attached to the chassis, the chemical analysis of each part was closely controlled and the specifications for physical properties were established with these chemical limitations in mind. In Table 2*A* are shown the physical property requirements for the chassis parts and in Table 2*B*, the chemical analyses of the materials used.

All of the welds shown in the illustrations are single bead, plain-carbon steel, covered electrode, metallic arc deposits. For the frame proper, a low-carbon steel backing-up strip is employed with little scarfing or other preparation of the welded joint required. Pick-up of alloying elements from the alloy plate during welding assures weld metal physical properties comparable with the values characteristic of the plate material. Check tests give results similar to those shown in Table 1.

Cost Data

Comparable total labor costs for riveted and for welded constructions were developed for the chassis. The estimates indicated that 282 man-hours of labor would be required for riveted construction and only 218 man-hours of labor for welded construction. A charge of $0.004 per pound of metal for stress relieving was applied against the welded construction total labor charge. In these preliminary estimates, assumption was made that the material costs would be about the same and no effort to develop relative costs in terms of material differences was made. Based on an hourly rate of $1.20, this preliminary estimate indicated that a saving of $76.80 per chassis could be effected if welded construction were adopted. Actual costs of welded construction reported during May 1942, are as shown in Table 3 in comparison with the estimated welding costs.

Table 3

	Estimated Costs	Actual Costs
Material	....	$167.31
Labor involved in welding	$ 68.40	74.80*
Total labor	261.60	238.20
Stress relieving cost	4.34	3.91
Total cost (this does not include overhead or any profit)	433.25	409.42

* The actual welding time exceeded the estimate because of repairs made necessary by critical Ordnance inspection.

Top Carriage

After the advantages of the welded construction applied to the chassis had been developed, a study applied

Fig. 12—A View of a Portion of One of the Outriggers at the Location of the Swivel. This Swivel Is Used so That the Outrigger May Be Folded Into the Main Body of the Chassis During Travel. Note in This View That the Handle Lock Is Riveted on as Is the Stake Bracket

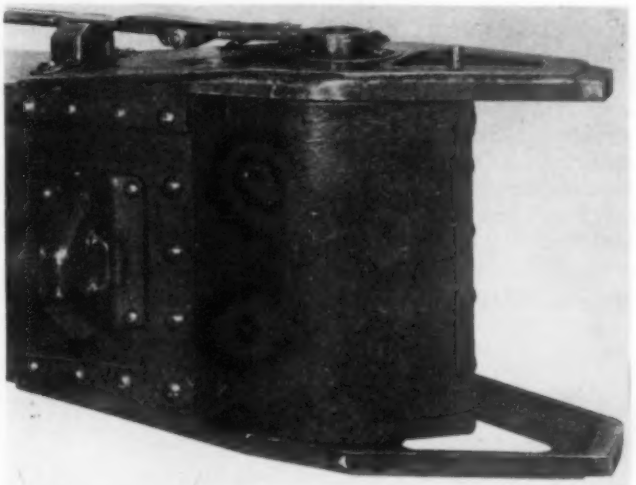


Fig. 13—A View of the Welded Construction Used for the American-Made Outrigger. Note that the Handle Lock and Stake Bracket Are Also Welded

Table 4A—Physical Properties of Parts Used in the Top Carriage

Part Name	Material	Yield Strength, Psi.	Tensile Strength, Psi.	Elongation, in 2 In., %	Reduction of Area, %
Turntable	Low-alloy, high-strength steel	50,000	95,000	20	..
Side plates	Low-alloy, high-strength steel	50,000	95,000	20	..
Base bearing	WD 1020	40,000	60,000	20	40
Brackets	WD 1020	40,000	60,000	20	40
Spacers	WD 1020	40,000	60,000	20	40
Bearing	WD 1020	40,000	60,000	20	40
Boss	WD 1020	40,000	60,000	20	40
Clip	Low-alloy, high-strength steel	50,000	95,000	20	..
Bushing	WD 1035	65,000	81,000	16	..
Spacers	Low-alloy, high-strength steel	50,000	95,000	20	..
Body tube	Low-alloy, high-strength steel	50,000	95,000	20	..
Stop	WD 1020	40,000	60,000	20	40

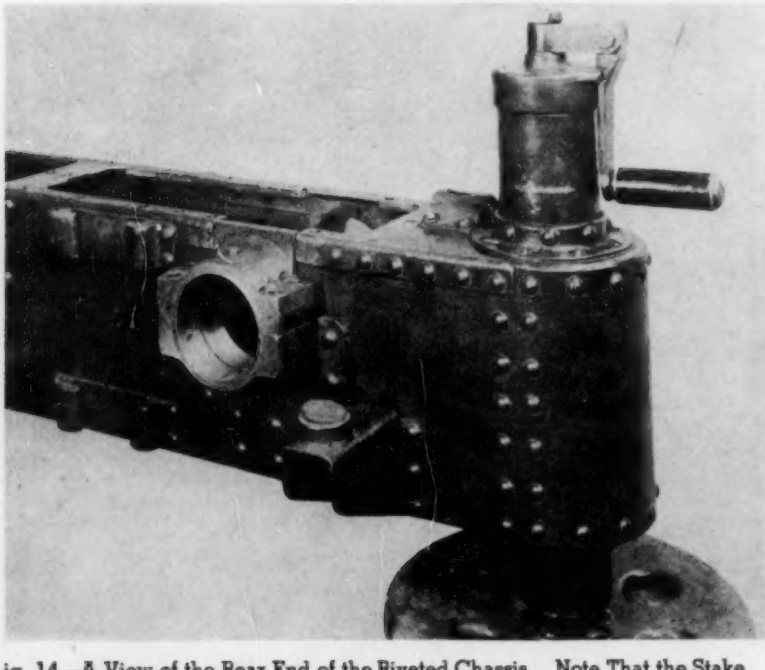
Table 4B—Chemical Analyses of Materials Used for Parts of the Top Carriage

Material	C	Mn	P, Max.	S, Max.	Cr	Other Elements
Low-alloy, high-strength steel	0.10–0.20	0.50–0.70	0.040	0.040	0.50–0.65	Si 0.60–0.90 Zr 0.10–0.20
WD 1020	0.15–0.25	0.30–0.60	0.045	0.055	.....	.....
WD 1035	0.30–0.40	0.60–0.90	0.045	0.055	.....	.....

to the top carriage indicated that a welded design would be both cheaper and stronger. The redesigned top carriage weighs 300 lb. in comparison with a weight of 264 lb. for the foreign model of riveted construction and a calculated weight of 317 lb. if riveted and of equivalent thickness. This top carriage is made by attaching the uprights to the turntable which is fabricated by the employment of pressed and formed parts welded together. These parts are formed from the same quality steel used in the plate construction of the chassis. The high-strength, low-alloy steel plates forming the upright box section are punched, placed in welding jigs and edge and slot welded together. In Fig. 16 is shown a photograph indicating the general design features employed in the fabrication of the foreign model top carriage. A comparable view for the weldment is presented in Fig. 17. The different angle of mounting and the different bearing construction employed for the breech connection are apparent as are the slot type welds used in joining the side plates to the internal stiffeners. The physical properties and chemical analyses of the steels used in the fabrication of the top carriage are presented in Tables 4*A* and 4*B*.

Summary of Subassembly Weights and Cost Savings

In Table 5 is shown a summary of the weights for the important redesigned welded subassemblies, the comparable weight for the English model and the calculated



ig. 14—A View of the Rear End of the Riveted Chassis. Note That the Stake uides, the Bearing Supports and Other Parts Are Attached by Riveting

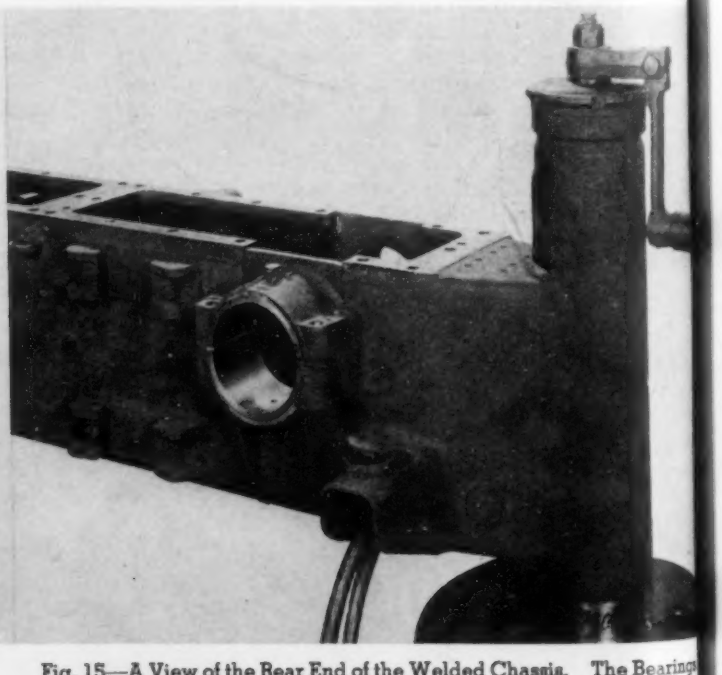


Fig. 15—A View of the Rear End of the Welded Chassis. The Bearings of the Powdered Metal Anti-friction Type, Which Have Recently Ga Favor in This Country

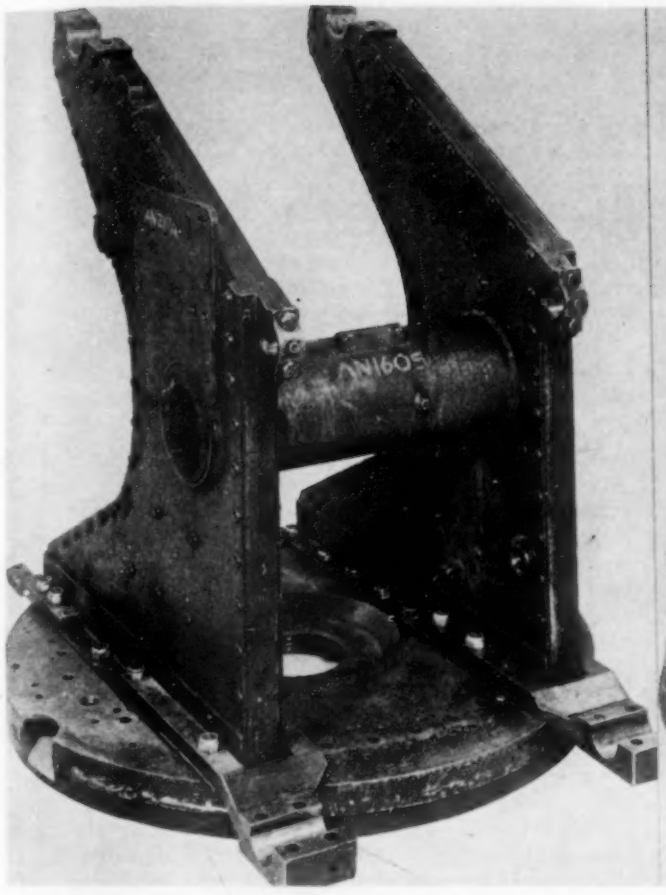


Fig. 16—A View of the Foreign Model Top Carriage Which Employed Riveted and Bolted Construction. The Base Plate or Turntable Was Made as a Forging

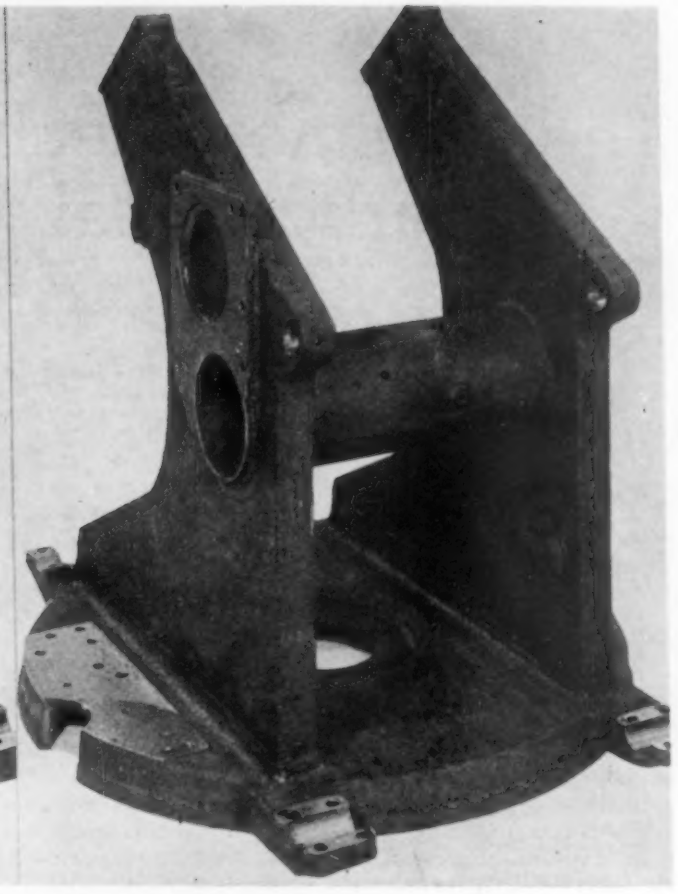


Fig. 17—The Redesigned Top Carriage. Greater Strength and Neater Appearance at Reduced Cost Have Been Obtained

weight of a riveted design having the same metal thicknesses as are present in the welded carriage.

Table 5—Weight Comparisons

Part Name	American Welded Model	English Riveted Model	Calculated Riveted Model
Chassis	1084	824	1155
Top carriage	300	264	317
Gear sector	38.5	42	42
Front axle	114	97*	121
Rear axle	114	84*	108
Stake (4)	21.5	18	22
Foot plate (4)	9.5	7.5	10.0
Gun stay	60.5	58.5	62.0

* As previously explained, these parts are not riveted but forged.

In view of the nature of many of the subcontracts, it is not possible to show in a definite way the money savings that have resulted from the employment of welded construction. From the information now at hand, the indicated saving is approximately $160 per gun carriage. This saving appears large until it is realized that the cost of materials and the cost of the close machine work required on so many parts which are in no way influenced by the welded design, makes the actual saving rather small in terms of the total cost of the gun carriage.

Closure

In times as momentous as these, cost in itself cannot be a deciding factor in the determination of a particular Ordnance design. Speed of production and efficiency and reliability during field operation are of greater importance. Several design changes were incorporated in the 40-mm. gun carriage in order to facilitate production and to improve operation. In achieving these results, the most important change was the conversion from a riveted to a welded construction.

Fundamentally, cost is the sum total of the number of man-hours of labor required to produce a completed unit or number of units. A decrease in cost may be translated to mean an increase in production of units with a given amount of labor. The adoption of the welded design produced an appreciable saving in the final cost of the gun carriages and, therefore, more carriages are now being made within a given period of time.

This mobile carriage is equally well adapted to defensive and to offensive operations. Who knows but that these additional units made available through the ingenuity of designers and engineers, unwilling to slavishly follow a pattern that had been considered good enough by others, will not some day prove to be the deciding factor in achieving victory. Our present huge armament program undoubtedly offers many other examples of American inventiveness directed to this same end.

"For the want of a nail the shoe was lost,
For the want of a shoe the horse was lost,
For the want....."

Poor Richard, Benjamin Franklin

The Common Mechanical Properties of Carbon-Steel Weld Metal in Electric Arc Welding*

By Orville T. Barnett†

WITH war the order of the day, an exact knowledge of the common mechanical properties of carbon-steel weld metal has become more important than ever. New designs are constantly being developed to take full and complete advantage of strength and ductility values. Alloying elements which have been plentiful in the past are no longer available for increasing strength or for enhancing ductility except where all other means of accomplishing such results have been exhausted. Thus ingenuity on the part of the welding engineer in applying the common welding electrodes to the limit of their usability has become a definite factor in furthering the war effort.

In welding, as in any other fabrication method, there are rules governing performance that attempt to produce specific results. Rules are laid down, for example, covering joint design, position of welding, type of electrode, size of electrode, welding current, arc length, interpass temperature, method of applying weld metal, postheat treatment and many others. Each of these factors exerts a definite control over the final results obtained. Therefore a detailed review of the several causes and effects resulting from different welding procedures should aid in establishing a comprehensive welding plan to achieve a definite set of mechanical weld metal attributes.

An outstanding contribution to the study of the mechanical properties of weld metal was made by the United States Navy when it standardized testing procedures. Both the AMERICAN WELDING SOCIETY and the American Society for Testing Materials recognized the value of this contribution and incorporated the salient features in a specification for arc-welding electrodes bearing the serial designation A.S.T.M. A233–42T. By following this specification through its carefully prepared instructions a sound conception of the principal welding variables can be gained. For the sake of simplicity, however, only welds in the flat position will be discussed.

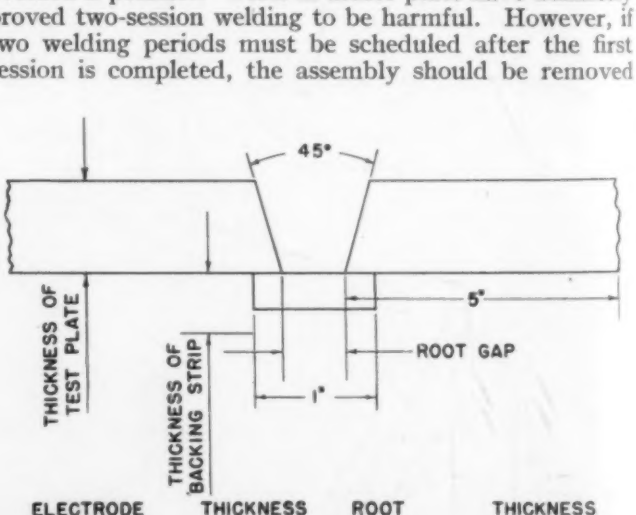
Of fundamental interest is the test-plate shown in Fig. 1. Here the dimensions of the plate, width of gap at the root and thickness of the backing strip change as the diameter of the electrode being tested increases. The size of the test-plate has been selected both to allow ample heat capacity and to provide a practical cooling rate. The root gap has been chosen to permit sufficient room for arc manipulation, and the thickness of the backing strip has been adjusted to the width of the gap to prevent burning through when larger electrodes are used. Often the root gap is established by joining the backing strip to the two beveled plates with small continuous fillets.

In an effort to maintain uniform test conditions during repetitive tests the plate is insulated from the top of the welding bench by a 1/2 in. pad of asbestos during welding. After the joint has been tacked together, the entire test-plate assembly is heated in boiling water for 5 min. before the deposition of the first bead. After each pass has been completed, the assembly is permitted to cool on the asbestos pad in still air for 10 min. Next the plate is immersed in boiling water for 5 min.

Each pass is made immediately after removing the plate from the boiling water. The cycle is repeated, pass by pass, until the last layer deposited for grain-refining purposes has been finished. A final 5-min. treatment in boiling water follows.

Time is a consideration in the standard test method. In laboratories electric alarm clocks are used to control the time of each operation. The type commonly used in photographic dark rooms has proved dependable and the insistent alarm that can ring indefinitely assures proper attention to this detail.

Sometimes it becomes necessary to weld a test plate on two successive days, although this practice should be avoided if possible. Tests in armor plate have definitely proved two-session welding to be harmful. However, if two welding periods must be scheduled after the first session is completed, the assembly should be removed



ELECTRODE DIAMETER (IN.)	THICKNESS OF TEST PLATE (IN.)	ROOT GAP (IN.)	THICKNESS OF BACKING STRIP (IN.)
1/8	1/2	1/4	3/16
5/32	3/4	1/2	1/4
3/16	3/4	1/2	1/4
7/32	3/4	1/2	1/4
1/4	1	1/2	1/2
5/16	1 1/4	1/2	1/2
3/8	1 1/2	1/2	1/2

Fig. 1—Standard Dimensions of Test Plate Used in A.W.S.-A.S.T.M. A233-42T Test Procedure

* Presented before Columbus Section, A.W.S., Nov. 13, 1942.
† Production Engineer, Welding Div., Metal & Thermit Corp., New York, N. Y.

from the boiling water following the 5-min. period and then allowed to cool in still air at room temperature. When the second session is to begin, the assembly is first preheated in boiling water for 5 min. and then the work is carried on in the usual manner. Room temperature is assumed to be a minimum of 60° F.

Prior to the adoption of a detailed procedure for establishing the simple mechanical properties of all-weld-metal specimens, there were as many methods of welding plates for determining such properties as there were welding engineers interested in the problem. Interpass temperatures which have a pronounced effect upon resulting properties varied anywhere from 100 to 500° F. Nor was any attempt made to standardize these temperatures, and successive plates might be welded with either the maximum or minimum interpass temperature or any heat level in between. Results under such conditions of test were most erratic.

The introduction of the standardized interpass temperature, together with the establishment of a fixed cooling cycle employing boiling water as the cooling medium, proved to be a valuable contribution. Subsequent to its adoption, agreement between tests have reached a gratifying consistency.

The mechanical properties of weld deposits bear a direct relationship to the interpass temperatures encountered during welding. High interpass temperatures tend to lower the yield strength and the ultimate strength of the deposit, at the same time increasing both the elongation and the reduction of area. Conversely low interpass temperatures lead to high values both for yield strength and for ultimate strength with corresponding reduction both of the elongation and of the reduction of area.

Of course the thickness of each pass has an important bearing on the final results. For this reason the standard procedure recommends that no layer be thicker than $^1/_8$ in. In actual practice the number of passes vary from 9 to 11 for a 1-in. plate. Nine passes are encountered in tests to determine the mechanical properties of deposits such as those made with Grades E6010 and E6012 electrodes while 11 passes are found in tests of Grades E6020 and E6030. This is logical as the former are of the quick solidifying types with somewhat viscous deposits, while the latter are of the so-called "hot rod" types with fluid deposits.

Since the number of layers in a welded joint influences the final cost of the weld, welding engineers have gone to great lengths to keep the number of passes to a minimum. However, there is a limit to which this cost-saving reduction in the number of layers can be carried without endangering the physical make-up of the weld deposit. Grain refinement in multipass welds results from the heat-treating cycle introduced when one layer is deposited on top of another. The depth of heat penetration is limited by joint design to about $^1/_8$ in. under normal welding conditions. Therefore, very thick layers are liable to lead to only partial grain refinement with the resulting structure consisting of regions having alternate strata of fine and coarse grains. Such structures have frequently exhibited inferior ductilities. Besides, the desirable yield and ultimate strengths of fine grain structures are usually lacking. As a rule, then, thick layers should be avoided.

Generally speaking, the kind of plate used for making this particular type of test has little influence on the final results because the amount of dilution of the weld metal with parent metal is small. In industrial practice, however, the parent metal frequently has a pronounced effect on joint strength. For this reason, some recent armament designs have specified relatively light sections where the

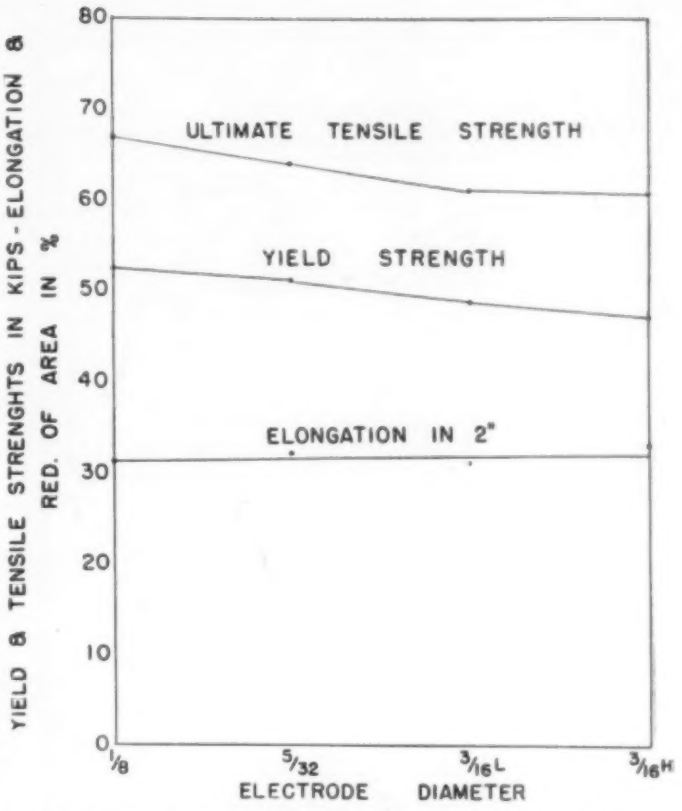


Fig. 2—A.W.S.-A.S.T.M. A233-42T Test Procedure. E6010 Electrodes—Deposit Stress Relieved

amount of dilution of the weld metal with parent metal has been pronounced. Some controlling specifications have listed rather high yield strengths which placed an appreciable burden on mild-steel weld-metal deposits. Where borderline results were being encountered, a simple change to an electrode whose deposit contained a small amount of molybdenum was instituted. The higher strength deposit that resulted ended controversies between inspectors and production engineers over results that were too close to the specified minimum yield strength for comfort. Good welding quality plate is required and carbon steel for boilers and pressure vessels (A.S.T.M. Designation A-70), or carbon steel for bridges and buildings (A.S.T.M. Designation A-7), both of which are listed by the A.W.S.-A.S.T.M. Specification under discussion, enjoy the widest popularity. Either open-hearth or electric furnace steel is suitable for making these tests although the open-hearth type is used almost exclusively for this purpose.

Because the design of the welding joint influences the final properties, a review of a number of test results in which various diameters of electrodes are compared with their physical properties appears to be worth while. First Grade E6010 deposits in the stress-relieved condition as illustrated in Fig. 2 will be studied.

At this point the fact that 0.252-in. specimens are used for testing $^1/_8$-in. diam. electrodes and 0.505-in. specimens for all larger sizes should be pointed out. Likewise, elongation values are reported in 1 in. for $^1/_8$-in. diam. electrodes with their subsize tensile specimens rather than in 2 in. as is true of the larger electrodes.

When Grade E6010 electrodes are tested, we find that both the ultimate strength and the yield strength decrease as the electrode diameters increase. The elongation shows but a very slight increase as the electrode becomes larger. When it is remembered that the size increase in the electrode is much greater than the dimension

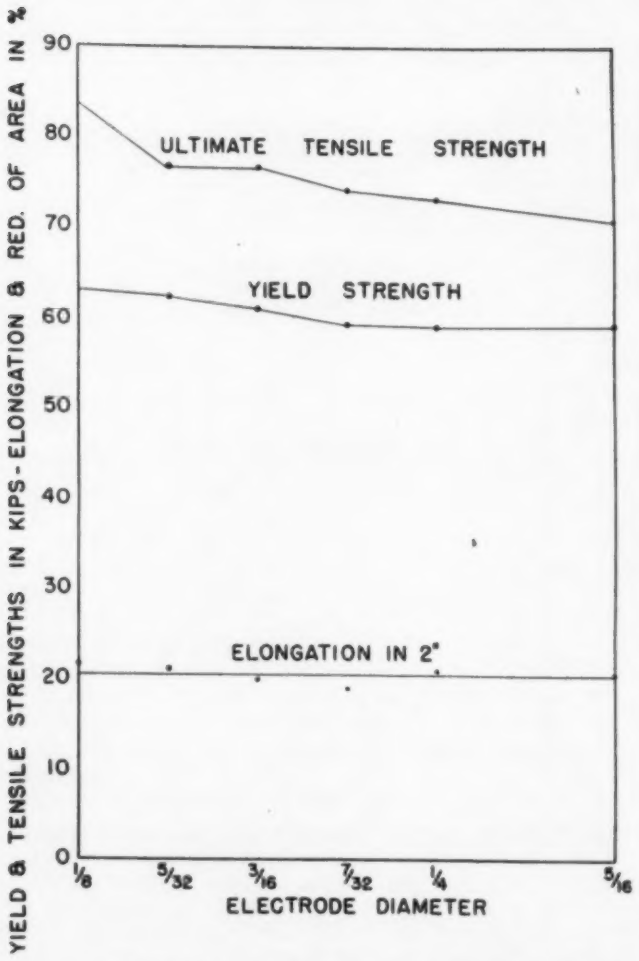


Fig. 3—A.W.S.-A.S.T.M. A233-42T Test Procedure. E6012 Electrodes—Deposit as Welded

increase in the test plate, this is not difficult to understand. With a greater ratio of heat input to the cooling capacity of the joint, the rate of cooling is reduced making for lower strength values.

Grade E6012 electrodes exhibit the same general relationships between electrode diameters and strength or ductility factors as did the Grade E6010 type. For variety, Fig. 3 is reported in the as-welded condition which has no effect on the general observations at all.

Turning to Fig. 4, where Grade E6020 electrodes in the stress-relieved condition are reviewed, we find these same general observations apply. Ultimate and yield strengths decline with increasing electrode diameter while the elongation remains substantially constant.

Of course, both current and arc voltage influence the final properties of the deposit. For this reason proper operating currents together with correct arc voltages always should be employed in making tests. In control work such as that done by electrode manufacturers where the mechanical properties of electrodes are studied periodically, definite current values are set up. Using this means of arriving at test information, any variations in arc voltage become functions either of the operator or of the electrode. With highly skilled operators, and this type of operator is always used in important physical test work, the general variation in arc voltage derives from the chemical, physical and mechanical make-up of the electrode.

Almost everyone is familiar with the necessity for holding a short arc with Grade E6012 electrodes. A short arc brings about a lower arc voltage than does a long arc. In addition the short arc assures a complete protection of the weld metal while it is being transferred. A short arc usually leads to an increased ductility with but slight impairment of the strength factors. On the other hand a long arc allows much contamination, probably by nitrogen and oxygen from the air, with a marked difference in ductility as measured by elongation.

Table 1—Effect of Arc Voltage on the As-Welded Physical Properties of 1/4- x 18-In. Grade E6012 Electrodes Welded with Direct Current, Straight Polarity

(Average of 4 Specimens)

	275 Amp., 20.2 V.	275 Amp., 21.7 V.
Yield strength, psi.	59,500	62,500
Ultimate strength, psi.	72,750	73,400
Elongation, % in 2 in.	20.3	14.2
Reduction of area, %	29.5	22.3

Since Grade E6020 electrodes are noted for their outstanding ductilities, an increase in arc voltage frequently becomes desirable because of a changed condition of equilibrium between slag and deposit. This condition frequently improves yield strength and ultimate strength

Table 2—Effect of Arc Voltage on the Stress-Relieved Physical Properties of 1/4- x 18-In. Grade E6020 Electrodes Welded with Direct Current, Reverse Polarity

(Average of 3 Specimens)

	325 Amp., 29.4 V.	325 Amp., 34.9 V.
Yield strength, psi.	43,333	46,500
Ultimate strength, psi.	59,417	63,333
Elongation, % in 2 in.	35.8	32.8
Reduction of area, %	60.3	57.1

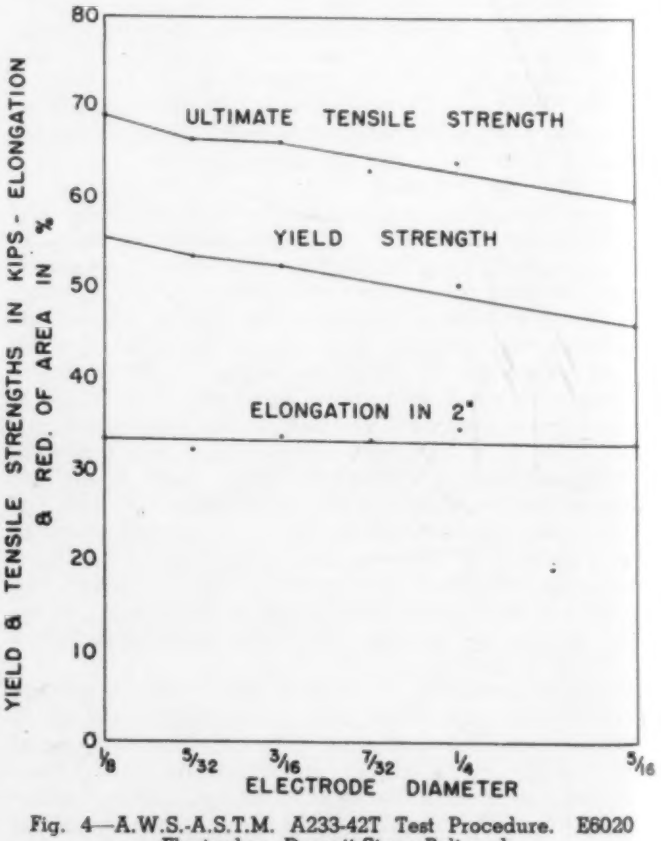


Fig. 4—A.W.S.-A.S.T.M. A233-42T Test Procedure. E6020 Electrodes—Deposit Stress Relieved

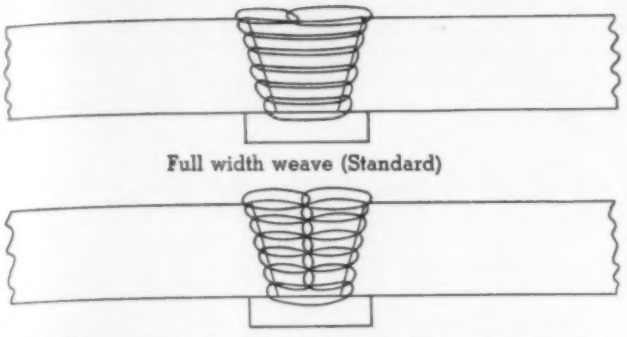


Fig. 5—Techniques for Determining the Mechanical Properties of Electrodes

with but a slight reduction in ductility. Table 2 shows the result of this type of study.

A.W.S.-A.S.T.M. test procedure calls for full width weaves until the reinforcing layer is reached. Here two parallel beads complete the final pass. In Fig. 5 this orthodox procedure is illustrated together with the split weave technique that has found favor in some types of weldments. The split-weave method of filling the groove brings about a higher yield strength, a higher ultimate strength without much effect on the elongation. Of course, parallel string beads mean more dilution of the weld metal with parent metal although this is not a prime cause of the improved mechanical properties. As a general observation it may be stated that increasing the number of beads as is done in the lower part of Fig. 5, through better control of the weld metal and through more perfect grain refinement, brings about the changed physical properties.

Table 3—Comparison of Stress-Relieved Physical Properties of 1/4- x 18-In. Grade E6020 Electrodes Welded with Full Width Weave and with Split-Weave Techniques

Weave	Yield Strength, Psi.	Ultimate Strength, Psi.	Elongation, % in 2 In.
Full width	46,750	60,650	30.4
	48,250	61,200	31.2
	47,500	64,500	35.1
	47,000	63,500	34.3
	46,000	62,500	37.5
	47,000	62,500	34.4
Split	52,500	67,000	33.6
	51,000	66,000	33.6
	51,500	65,500	35.1
	54,500	64,000	34.4
	52,000	63,500	36.0
	49,500	62,500	35.1

Table 3 shows the results of using both normal and split-weave techniques. And Fig. 6 is a graphical presentation of the averages developed from Table 3.

The specification for determining the properties of deposited weld metal calls for results both in the non-stress-relieved (or as-welded condition) and in the stress-relieved state. Since stress relieving is a heat treatment below the critical range intended to relieve internal stresses built up during welding, both temperature and time play an important role in any stress-relieving operation. The specification states that stress relieving, when prescribed, is for the purpose of developing the fundamental properties of the weld metal unaltered by locked-up stress. The heat treatment is specifically detailed and designed to bring about a substantially stress-free state. Stress-relieving temperature is specified as being within the range of 1150 ± 25° F. for 1 hr. per inch of thickness. The specifications also state that the specimen shall be placed in a suitable furnace and heated at the rate of 300 to 350° F. until the desired range has been attained. After the temperature of 1150 ± 25° F. has been reached, it should be maintained for one hour for each inch or fraction thereof of the maximum thickness of the section. Then the specimens are to be cooled at the same rate specified for heating and may be removed from the furnace when the temperature of the plate has reached 300° F.

The stress relieving is a tempering or drawing operation. As such any increase in stress-relieving temperature should bring about a reduction of strength factors and an increase in ductility factors. Figure 7 shows that this is the case.

Equally as important as temperature, although its effects are somewhat less, is the matter of time. In Fig. 8 the yield strength, the ultimate strength and the elongation of weld metal deposits are compared using identical stress-relieving cycles except that one group of specimens was held at the stress-relieving temperature for 1 hr. and one group for 4 hrs. This too reduces the strength factors while increasing the ductilities.

Discussion frequently arises as to the relative merits of alternating and direct current and for their influence on the physical properties of weld deposits. Usually alternating current has been credited with improving deposit characteristics. However, as may be seen in Table 4 some alternating-current tests result in lower strengths and greater elongation. It should be recognized, however, that these alternating-current tests were run at a higher current setting than were the direct-current tests and that, in addition, arc voltage was lower for the alternating-current tests. When the many controlling factors that contribute to the simple mechanical properties of weld deposits are taken into account, it may be appreciated that generalizations on the relative merits of alternating- and direct-current deposits are subject to considerable analysis. Certainly it is not proper to conduct alternating- and direct-current tests at the same current.

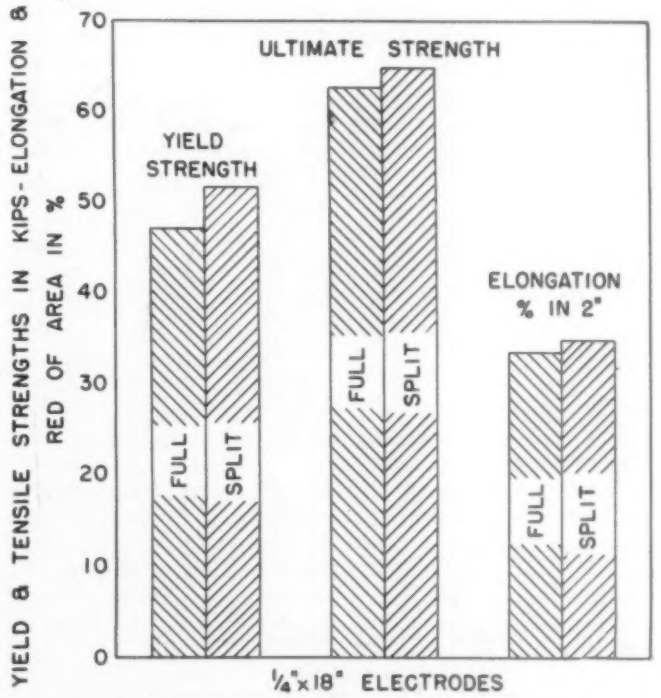
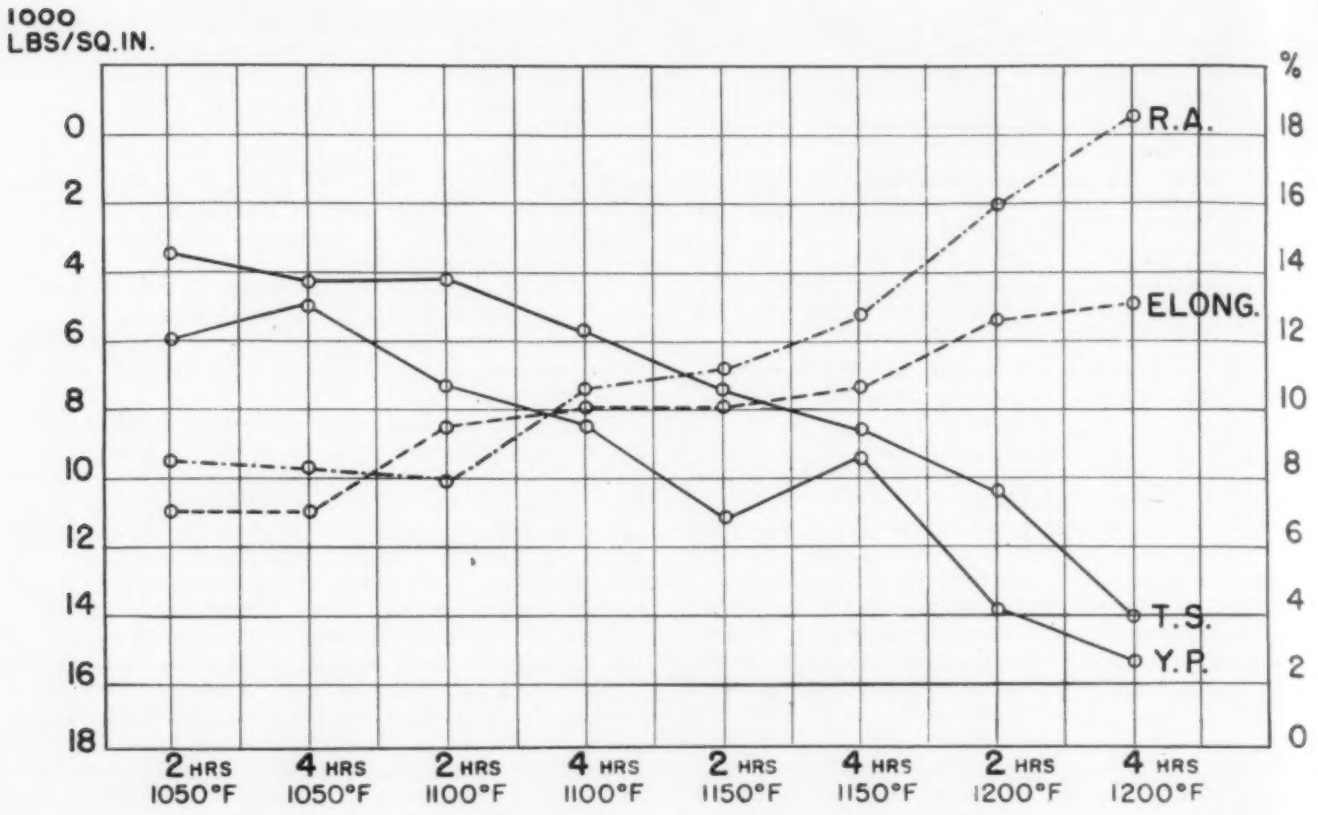


Fig. 6—A.W.S.-A.S.T.M. A233-42 Test Procedure. E-6020 Electrodes-Deposit Stress Relieved. Comparison of Mechanical Properties Using Orthodox Full Width Weaves and Split Weaves



NET CHANGES OF Y.P., T.S., EL. AND R.A.

Fig. 7

Because of the alternations of the current, for example, a greater amperage is needed with alternating current, to secure the same rate of deposit. Perhaps comparative tests might be undertaken using current values designed to give equal rates of deposit. With similar arc voltage the resulting mechanical properties should be an index to the influence of the type of current.

Table 4—Comparison of Stress-Relieved Physical Properties of 1/4- x 18-In. Grade E6020 Electrodes Welded with Alternating Current and with Direct Current, Reverse Polarity

Current	Amp.	Volts	Yield Strength, Psi.	Ultimate Strength, Psi.	Elongation % in 2 In.
A. C.	334	35.7	52,500	62,000	39.5
			51,500	61,500	35.1
	350	32.2	48,000	62,500	33.6
			48,000	62,500	39.8
D. C.	330	36.0	52,500	67,000	33.6
			51,000	66,000	33.6
	328	35.7	51,500	65,500	35.1
			54,500	64,000	34.4

Thus the apparent differences in results shown in Table 4 are probably more influenced by voltage and amperage conditions than any other factors. All of the results listed comply with the minimum established by the controlling specification quite well. Therefore, any conclusions from such diverse and limited test information are quite likely to be erroneous.

As both alternating and direct current have their place in welding, with the present war effort placing emphasis on the desirability of using alternating current wherever possible, it must be recognized that both types of current, when properly used, give excellent results.

In view of the large savings in critical material which alternating-current transformers make possible when substituted for single-operator direct-current motor-generator sets, the War Production Board is rightly attempting to switch as much work to alternating-current equipment as possible. In addition to the savings in critical material, the manufacturing time needed to make alternating-current units is less, which means that

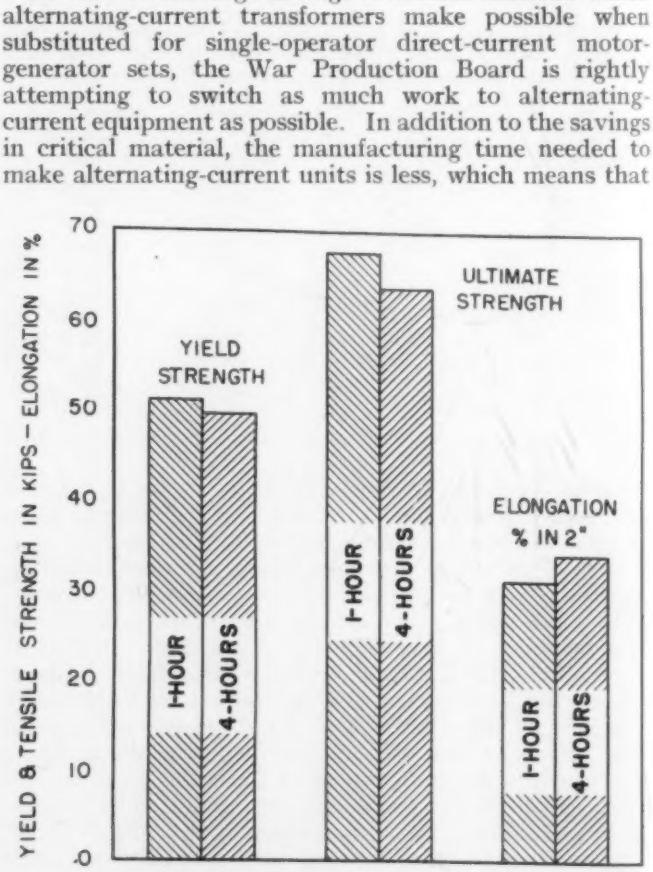


Fig. 8—Effect of Time at 1150° F. on Common Mechanical Properties of Grade E6020 Deposits

a tremendous backlog of orders for welding units may be more expeditiously filled. With positioned work another *must* because of the shortage of welding equipment and of welding electrodes, the trend to alternating current with its freedom from the disturbances of magnetic blow becomes most worth while.

In this discussion, reviewing a standard test procedure for arriving at the mechanical properties of weld deposits, an attempt was made to highlight the most influential factors. Every joint design and every welding procedure that differs from the standard reviewed here will give other results. Therefore, in comparing physical properties as obtained under field conditions it is quite essential that the differences between field-welding practices and the test practice used to establish the properties of the weld deposit be taken into consideration. It is hoped that this brief discussion of the elementary controlling influences may lead to a better understanding of the relationship between physical properties of welds in actual weldments. Further, an attempt was made to present some clues as to the possibility of changing conditions to meet some particularly trying phase of a specification.

Training of Welding Foremen*

By F. H. Achard†

FUNDAMENTALLY, the training of welding foremen is quite similar to the training of foremen in any other field. There are, however, a few points that seem to be worth special emphasis.

Before we start, a definition is in order. In many companies the foreman constitutes the third level or even the fourth level of supervision; in others he constitutes the first level of supervision. In this discussion the term "welding foreman" will be assumed to include supervisory employees of the first and second levels and possibly the third level of full-time supervision, thus excluding the working foremen, gang pushers, etc., on the one hand, and management on the other.

The training of welding foremen, like the training of any other kind of supervisory employee, fundamentally begins with his selection, and selection of the welding foreman is very much influenced by the characteristics of the welding job and of the welder as distinguished from other types of occupations and operators.

Characteristic Features of Welding as an Occupation

Welding is one of the youngest of the trades or crafts. One can acquire elementary skill in it in a relatively short time, just as one can learn to operate some of the simpler machine tools. It is, however, fundamentally a handicraft, except in the few cases where automatic welding equipment has been installed, and as such the quality of work depends upon the muscular control and coordination of the welder. If the operator has what it takes he can reach a relatively high degree of skill probably in a shorter time than a machinist or a carpenter can reach a corresponding degree of skill. If he doesn't he will probably never acquire it.

Welding is an operation that is performed under a variety of degrees of comfort and discomfort induced by heat, eye strain, cramped positions and the like. In this respect it requires a greater general physical endurance and perhaps a greater patience than many other trades. Because of the characteristics of the flame or arc, welding is done by individuals or small groups in comparative isolation even though many operators of other crafts are working in adjacent areas.

Welding is a craft that requires a high degree of sense of craftsmanship and fundamental honesty. The inspection of welds, unless they are under continuous observation or unless it is possible to X-ray every foot of weld in an operation, must be by a sampling process or by superficial inspection, and defects may not show up until a critical strain is put upon the weld.

Characteristics of the Welder

The welder, on the average, is probably somewhat younger than the members of other crafts.

Because of the nature of his work, he must have a high degree of muscular control and coordination between hands, eyes and ears which he can maintain over a long period of time.

He must be able to work in cramped positions and withstand localized high temperatures for a long period of time and, at the same time, control the rather bulky and awkward equipment and protective devices that he must, of necessity, use.

It is also necessary for him to be continuously aware of the fact that he is handling live equipment which can cause a great deal of damage if it gets out of control even momentarily, and loss of control can easily be accomplished by a moment's inattention.

He is probably more of an introvert than an extrovert, and is quite ready to work alone, and to pay strict attention to his job even in the midst of considerable noise and confusion on the one hand, and in the absence of human contacts on the other.

He must also be thorough and painstaking in his work. While he must maintain a production schedule, he must also be very sure that every fraction of an inch of his work measures up to the required standards. In his work even "99.44%" is not good enough.

Finally, he must perform his work under a relatively limited condition of supervision and inspection.

Special Features of the Welding Foreman's Job

The welding foreman, perhaps even more so than the machinist or carpenter foreman, must be a skilled craftsman. Not only that, but he must also know how to lay out a job, select the requisite welding rods and establish

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† Supervisor of Training, Consolidated Edison Co. of New York, Inc.

the sequence of operations so that the work can be performed without warping or blocking. Even in large-scale operations where a planning department performs these functions, the foreman should know how to do them so that he can report factors that may have been overlooked by the planning department but must be taken care of.

He should know the characteristics—both surface and internal—of a good weld and be familiar with such details as the rate at which metal can be deposited so that he can at least superficially check a weld and sense whether it has been done according to the requisite standards.

He should be able to size up a job to determine whether the working conditions are such that a weld can be made, and also be able to determine what changes in conditions should be made in order to do the job more economically or better from an over-all point of view.

He should be able to communicate his instructions and his ideas not only to welders, but also to engineers and to laymen in terms they will understand.

He should know how to instruct and to develop his welders to the extent of their respective capacities.

Of greatest importance, he should know the welders in his gang thoroughly, including their respective abilities and degrees of skill, their physical and temperamental characteristics and habits and their attitudes—not only generally, but also as they change from day to day. It is the foreman's job to assign specific welders to specific jobs. Some men can do one kind of weld and not another; some men can work under certain physical conditions, whereas others cannot; some men can work with or in the presence of certain people and not with others; and the welder himself will vary from day to day according to his physical and emotional condition, and one day be fitted for a particular job and another day not. The welding foreman should also know those who can be left alone with instructions to do a job and those who need frequent supervision. It is the welding foreman's job to know his men so thoroughly at all times that he can assign to each job the best men who are available.

Selection of Welding Foremen

It is perhaps obvious that a man, to be selected for the job of welding foreman, should possess the abilities, the knowledge and skill and the characteristics that will enable him to perform the functions of a welding foreman before any effort at all is spent on training him. There is no sense in attempting to train a draft horse as a racer. Selection will normally be from the ranks of the most competent welders and straw bosses, but not necessarily the senior ones among them. At present, selection is based on job performance, personal history, the display of "leadership" characteristics and the opinion of the supervisory staff. The use of standardized tests and measures as an aid to the other methods of selection could probably be investigated.

Training Welding Foremen

Training programs for welding foremen differ. Some companies have preforemanship training courses in which working foremen and straw bosses may enroll. In other companies, organized training is confined to post-appointment training, if it is given at all. An ideal situation would seem to be to divide a training program into three stages—preappointment training, initial training after appointment and continuation training.

Preappointment Training

Preappointment training, given to top-grade welders and to working supervisors, can be used not only to prepare them for supervisory positions when such become open, but also to sift out those who do not seem to have such of the characteristics of a good welding foreman as can be displayed in a training program.

Training programs of this type are generally conducted by the conference method and include the discussion of the common supervisory activities such as selecting people for specific jobs, giving instructions and orders, giving reprimands, making supervisory inspections, training new and experienced employees, handling and preventing minor grievances, and the like; and might also include some of the elementary phases of welding technology. While it is not necessarily true that candidates who can handle such a course satisfactorily will be good foremen, there does seem to be some relation between lack of ability to handle such course material and lack of success in a foreman's job.

It is perhaps obvious that, from an organizational point of view, attendance at such preappointment training courses should neither by statement nor implication carry with it the promise of appointment. This point is so serious that many organizations are reluctant to install preappointment courses because of the feeling that no matter what is said, an employee who does well in such a course expects to be tried out as a foreman.

Initial Training After Appointment

Whenever a person undertakes a new job he must learn the specific duties and routines that belong to that job no matter what his preparation may have been. Among these are routine matters such as production reports, time reports, and company policies that affect his relations with the employees which may or may not have been covered in the preappointment training, but which certainly must be learned thoroughly by the new foreman upon his appointment; and he must learn how to put into practice the fundamental principles of good foremanship regardless of whether he has studied those principles in any preforemanship training program.

The new foreman can learn these things the hard way by burning his fingers, or he can be given a rational initial training.

If he learns these things the hard way, he will make mistakes and the mistakes may be costly to the company; they certainly will not help the new foreman to adjust himself as rapidly as he should. If, on the other hand, he is given brief instructions in the specific routines and activities expected of him, he will still probably make a few mistakes but they will be less serious than they will be if he is not given such training.

This initial training may be given to new foremen in groups, if there is a sufficient number of them having like activities, or individually. It will generally take but a relatively short amount of time measured in hours spread over a cycle of routine operations—perhaps one month, possibly one week.

Continuation Training

Perhaps the most important phase of training welding foremen is the continuation training. The training of foremen, from the very nature of things, is never completed, but the character of training activities for the experienced foreman differs radically from the character of preforemanship and initial training. He is no longer a novice and is daily gaining in experience. Consequently, to a considerable degree he is on a self-training basis.

The continuation training of foremen is essentially a

process of refinement. To be most effective, it is carried on by the conference technique, occasionally supplemented, when necessary, by the introduction of new ideas through lectures or bulletins. It may be divided into two or three parts—advancements in the art, changes in routines, and the handling of personnel problems.

Training in the advancement of the art can be done by means of talks, demonstrations, and discussions in foremen's meetings conducted by a higher executive and through the circulation of suitable publications.

Training in changes in routines may be handled through the circulation of memoranda or in foremen's meetings, and by individual contact between superintendent and the foreman.

Neither of these two phases of continuation training seems to offer many difficulties. They are fairly obvious and are generally handled reasonably well.

In recent years, however, there has been considerably greater attention paid to continuation training in the handling of personnel problems. It is generally recognized that no matter how carefully prepared and developed a foreman may be, he is likely to develop his own attitudes and habits of supervision which may or may not be the best ones that he could have. Many organizations have found that a program in which foremen are brought together for six or eight meetings a year to discuss the handling of various kinds of supervisory problems, and oftener when special conditions warrant, pays dividends by promoting the use among all of the foremen of the various methods which they themselves have found to be most effective. Such meetings also enable the management to inject additional ideas and suggestions in a way that the foremen will appreciate.

Such programs are generally built to fit the needs of individual organizations or divisions within an organization. Some companies use published courses or sound slide-films, of which there are several excellent ones on the market. Such material, however, must be used carefully, adjusted to the specific needs of the organization, and followed by discussions of specific organization and department problems if it is to be of greatest use. If a company is initiating a program, it may find it advisable to use a published course as a starter or nucleus unless it has talent available to construct a course especially suited to its needs.

Some companies are finding the services of the various State Departments of Vocational Education and of the Office of Education very helpful in building up specialized foremen training programs, and in some states, as in New York, the bureaus that are specifically interested in this sort of training have built up patterns of courses dealing with various supervisory problems that can be cut and trimmed to fit each company's needs, so that they essentially become hand-tailored jobs.

The Training Within Industry Section of the War Man Power Commission has developed an excellent program designed to teach foremen how to teach specific jobs to individuals. This program—known as the Job Instructor Training Program, or more popularly, JIT—has been given to over 200,000 supervisory employees and job instructors in all kinds of war industries throughout the country, and the training of foremen in just this one field has brought remarkable dividends. In addition, the Training Within Industry Section is organizing a series of short supervisory training courses to cover Job Methods Training and Job Relations Training, and I am informed that these will be released shortly.

Summary

The training of a welder foreman begins with his selection. He should be a good welder, should have some knowledge of the technology of his craft, and should be able to talk to other people in laymen's language about welding problems. He also should understand welders and the conditions under which they work. He should be able to recognize fully the abilities and characteristics of each welder in his group so that he will know what sort of work each welder can do well, under what conditions he can do his work with little supervision, and under what conditions he requires close supervision.

Some organizations provide preforemanship training in the fundamental principles of man-management and sometimes in some of the fundamental principles of welding technology. Other organizations start the training of welding foremen immediately after they have been appointed. The initial training after appointment should include the specific routines, policies, and practices that a foreman must know in order to function. If preforemanship training has not been given, it would be advisable to commence training foremen in the principles of man-management as soon after appointment as possible.

The third stage of training foremen is in follow-up or continuation training. This training is best done in foremen conferences in which the foremen exchange information about how they handle their problems, particularly in the field of man-management.

The use of published material can be very helpful for the training of welding foremen, but in each case it should be adapted to the specific needs of the organization.

As a final thought, the training of welding foremen and, in fact, the training of any kind of foremen is so important in these days that real training in the fundamental principles of man-management is highly desirable. As all methods of training foremen have been found to be useful, the wise thing to do is to select the method that appeals to the group and to start and to follow up the training.

1942 BOUND VOLUME

Bound Volumes of the JOURNAL of the Society for the year 1942 are now available with imitation black leather covers. Contains a wealth of information on the latest developments in welding. Also contains Subject and Authors' Index. Price, $5.00 plus postage to members; $6.50 to non-members plus postage.

Unusual Resistance Welding Developments and Operations*

By R. T. Gillette†

THIS paper should perhaps be started by asking a question. "What is an unusual development or operation in resistance welding?" It seems that this may be answered as follows: that it is a weld or a welding operation with which one is not familiar or, in other words, a welding job is unusual in inverse ratio to your familiarity with it.

There are a great many distinctly new and unusual jobs in the war program which cannot be discussed, so this paper will have to be confined to welding jobs and products which are made for peacetime use. Some of these may not be in production at the present time but will serve to suggest a method of solving some war problem or some job which is active at the present time. If this can be done, this article will have served its purpose.

One point that should be stressed is that unusual welding jobs are generally preceded by very clever design of the product to be welded. This in combination with some of the less common materials or alloys will give a product which may be outstanding. Most of the less common materials or alloys may be welded in similar or dissimilar combination.

If reliably welded parts are to be expected with a very low percentage of rejects on the less familiar product, the best available welding equipment, fully synchronous control, carefully trained supervision and operators and material which is cleaned with scrupulous care are prime requisites. In working out a technique for this type of welding, it is sometimes quite difficult to get the proper relation between the various welding factors and many times it is the unexpected procedure which gives the satisfactory job.

With some of the above points in mind, we will describe a few of the welding setups and products which may not be found in the average welding department with the hope that they will be of interest to you.

* Presented at the Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 12 to 15, 1942.

†Works Laboratory, General Electric Company, Schenectady, N. Y.

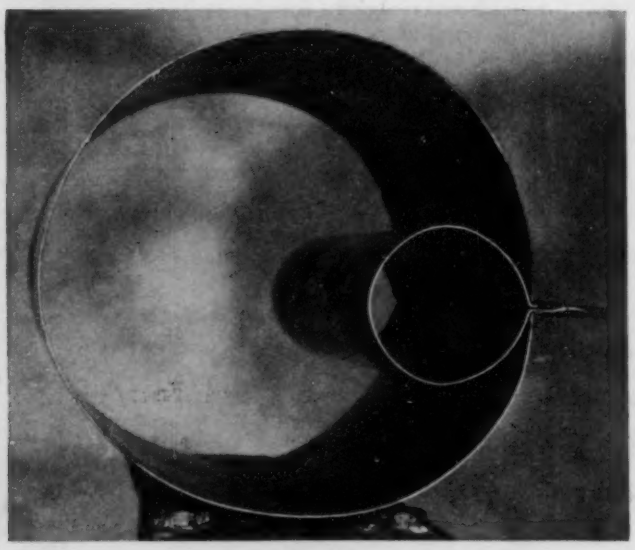

Fig. 1

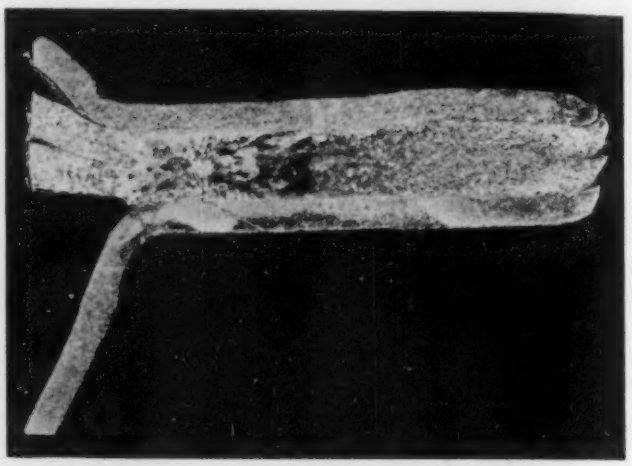

Fig. 2

A joint was developed to be used with a method of making heat-transfer surfaces or tubes of various shapes, one of them being shown in Fig. 1 where the smaller or inside tube is copper and the larger or outside tube is low carbon or stainless steel.

This tube could be made in several longitudinal sections with a joint at each side of each section which would give more metal to metal contact on a given job.

Figure 2 shows a macrograph of a seam weld joint between copper and low carbon steel. The welding procedure for this weld is not available.

Figure 3 shows a method of sealing a small mercury switch container; the two metal parts are chrome iron sealed across a porcelain disk with a glass ring with a small hole left in one iron piece to allow filling with mercury. Then the container is placed in a special projection welder in a pressure-tight electrode and hydrogen admitted at a pressure of 15 lb. above atmosphere. Next, a steel ball is placed over the hole and welded in place by pulsation welding. A continuous application of power does not work as satisfactorily, as it flattens the ball too much and in many cases pushes it through

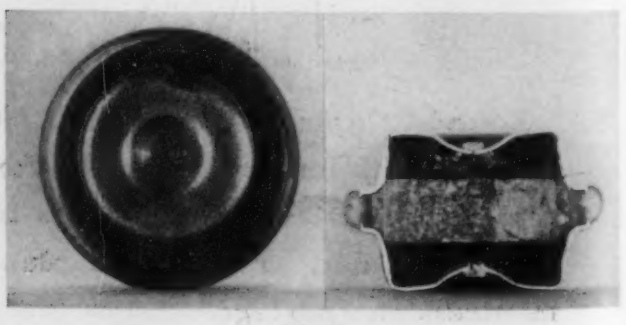

Fig. 3

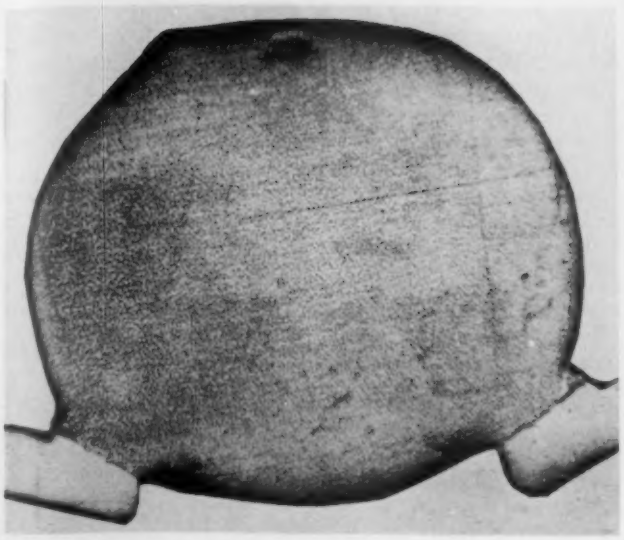

Fig. 4

the hole in the container without making a weld, while the pulsation method is very satisfactory.

This container is $^{3}/_{4}$ in. in diameter made of 0.010-in. stock and the ball is 0.062 in. diameter. Figure 4 is a macrograph of the ball welded to seal the hole.

In order to fabricate a flexible mounting for an operating rod for a small switch mechanism, two brass rods are prepared for projection welding by turning a 3-in. radius dome on the ends to be welded and projection welding then simultaneously on each side of a small drawn phosphor bronze cup. This complete assembly is 4 in. long and the bronze cup is 1 in. in diameter drawn from 0.005 bronze; this assembly is shown in Fig. 5.

The manufacture of a low carbon steel float, Fig. 6, 3 in. in diameter presented several interesting problems.

First the rectangular bracket made from $^{5}/_{16}$ x 0.044-in. stock was projection welded in place; this is a simple projection weld.

Fig. 5

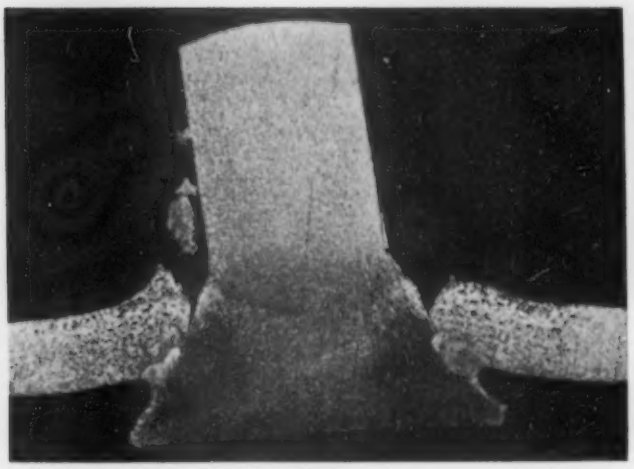

Fig. 7

The next operation is to spot weld the two halves together after the male and female parts are nested together to prepare them for copper brazing. This holds the two parts together as they go into the heat zone in the furnace and the air expands. These spot welds are made with an electrode on opposite sides of the float which makes two welds one on each side at the same time; a pulsation weld is used to keep distortion at a minimum. The welding procedure was pressure 100 lb., 3 impulses of power, 4 cycles on, one cycle off, 1600 amp

To allow breathing action and prevent leaks due to air contraction while cooling, a small hole is punched in one-half of the float which must be sealed as a last operation. This is done, by projection welding a taper head rivet or pin with an 0.050-in. diameter body and a 0.100-in. diameter head in the hole, as this must be welded in the float with no support on the under side of the part which is only 0.020 in. thick. Extremely light pressure (30 lb.) must be used and pulsation welding is also used to get better control of the weld and prevent pushing the pin through the hole. Welding procedure is as follows: 30 lb. pressure, 4 impulses of power, 1 cycle on, 3 cycles off, 315 amp. Figure 7 is a macrograph of this weld.

In several cases where parts are to be assembled and rotate on a shaft, welding has replaced the use of screws and lock washers as illustrated by the sketch shown in Fig. 8.

A low carbon steel piece made on a punch press and a brass bushing made on a screw machine, projection welded together, were used to replace a coined brass part for a small motor end shield and bearing, in a very satis-

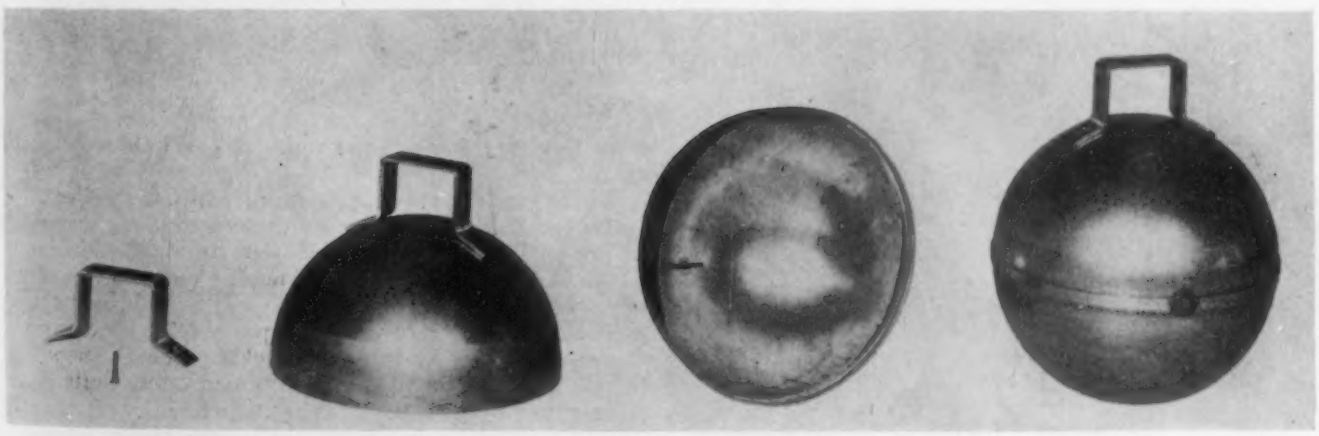

Fig. 6—Refrigerating Machine Ball Float Spot Welded by "Pulsation" Method

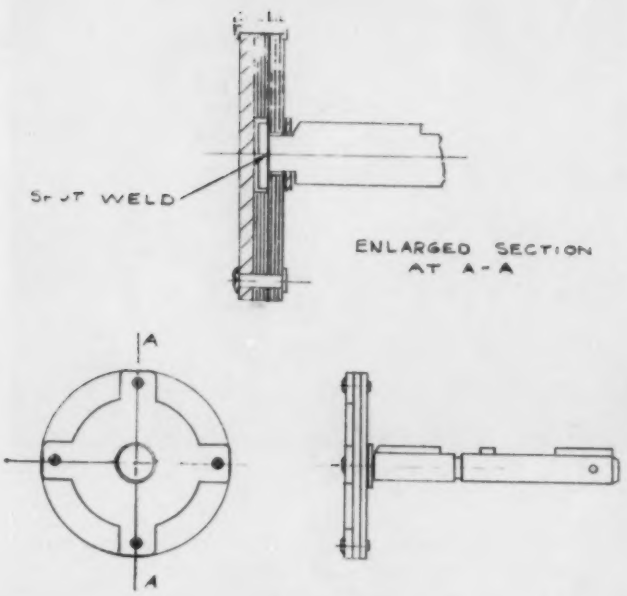

Fig. 8

factory metal substitution job and with a substantial reduction in cost. This part is shown in Fig. 9. There is an annular projection on both the steel and brass parts which line up together and form a very satisfactory weld; a section through this weld is shown in Fig. 10.

A small open coil (the size of this coil is shown by the ordinary pin in the photograph) wound from 0.005-in. enameled aluminum wire as shown in Fig. 11 had to have the ends connected to the terminals shown on each end. Aluminum solder could not be used as it was susceptible to electrolytic corrosion and the coils would become open circuited after standing a short time.

This difficulty was overcome by a combination of two welding jobs. A strip of metal, copper on one edge and aluminum on the other as shown in the left-hand view in Fig. 12, was made by butt welding copper and aluminum $^1/_4$ x 2 in. to each other, then rolling this down to a strip 0.005 in. thick, cutting off a piece $^3/_{64}$ in. wide which gave a strip 0.005 x $^3/_{64}$ x 1 in., one end copper and the other end aluminum, then folding over the aluminum end of the strip and placing the wire in the folded over portion of the strip and spot welding it in place. Then by soldering the copper end of the strip to the terminal we obtained a permanent joint not affected by corrosion.

The center view in Fig. 12 is a larger piece of copper-aluminum sheet made as described above.

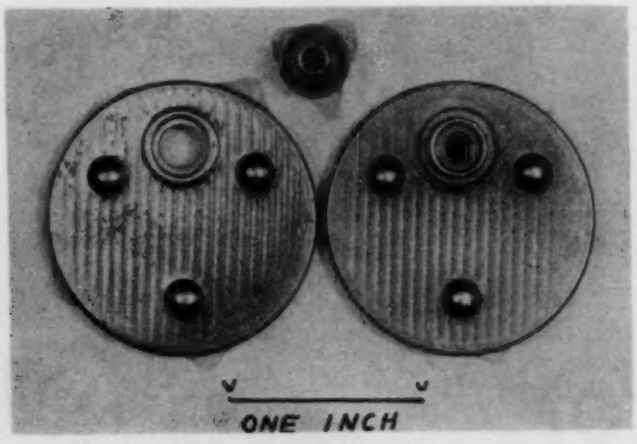

Fig. 9

The circular piece is a diaphragm made from stainless steel by rolling a channel from strip and then butt welding the ends to form a ring and seam welding a formed disk on each side.

The range of resistance welding in jobs which are unusual range from stainless steel spectacle frames and fountain pen points to complete stainless steel railroad trains and low-alloy freight and passenger cars.

Another little-known resistance welding job is the

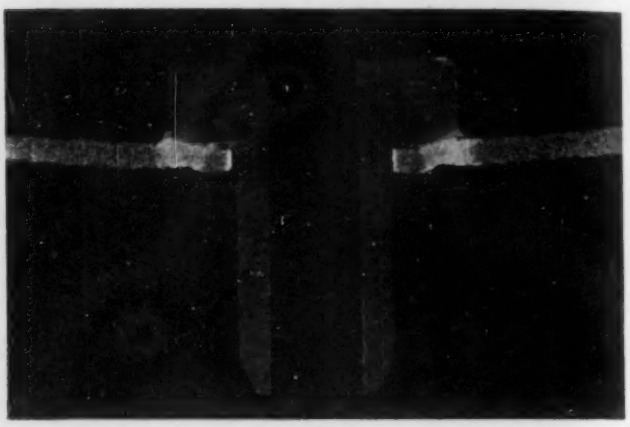

Fig. 10

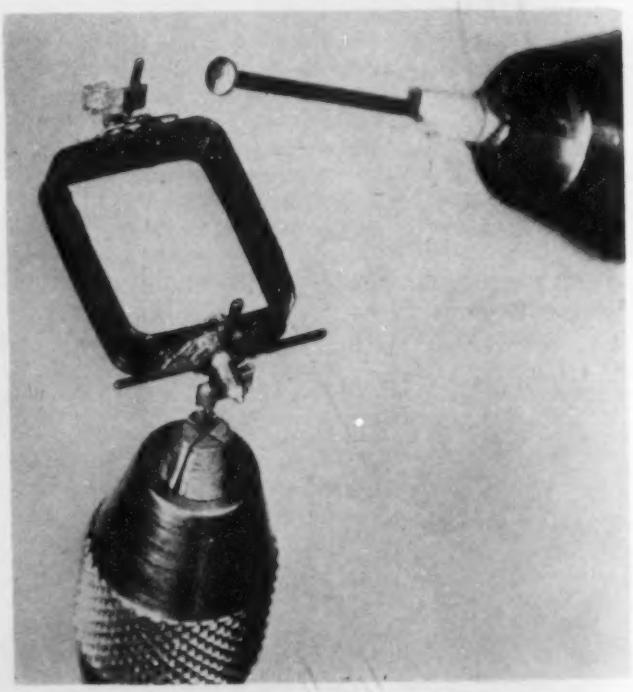

Fig. 11

flash butt welding of steel rails for continuous railroad track.

Welding and post heat treating various high carbon and other alloy steels is one of the outstanding activities at present and the results will undoubtedly be farreaching from the standpoint of opening an entirely new field of welding.

The development of various types of fully synchronous electronic control for resistance welding plus the new low inertia, low friction welding equipment being built gives an accuracy of operation without which many of the war jobs being done at present would be impossible.

Some of these controls are equipped with compensat-

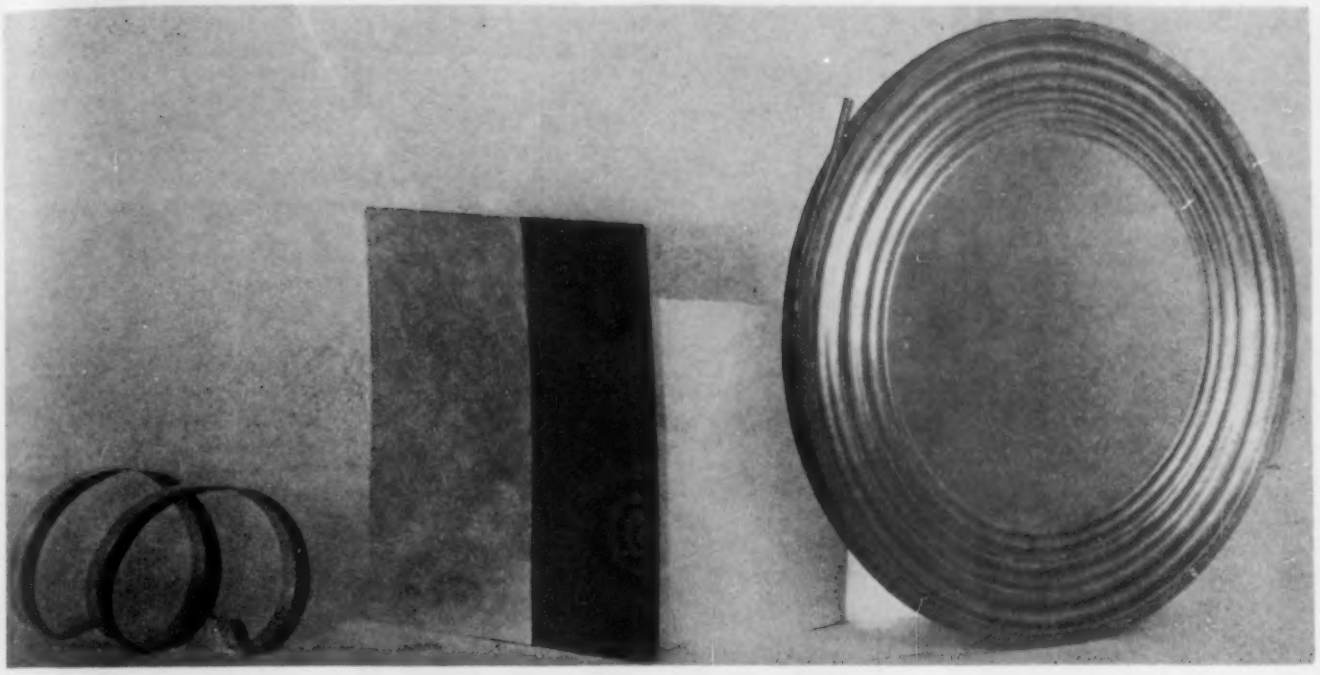

Fig. 12—(Left to Right) Bimetal Strip Formed by Rolling Butt-Welded Copper and Aluminum from 1/4-In. Down to 0.005-In. in Thickness. Bimetal Sheet Formed by Rolling 1/4 by 2-In. Butt-Welded Bars of Copper and Aluminum Down to 1/32 In.

ing devices which compensate automatically for voltage and current variation.

Another welding application which still creates a great deal of interest and is somewhat unusual is the welding of copper to aluminum. See article on "Resistance Welding of Dissimilar Metals," in October 1936 issue of JOURNAL OF THE AMERICAN WELDING SOCIETY; also "Resistance Welding Zinc-Alloy Die Castings," *ibid.*, January 1941.

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(*Continued on page 121*)

Training with the Aid of the Picture Screen

By Lyne S. Metcalfe

THE ever-growing demand for skilled welders in war production has developed a nation-wide program of instruction, in which the picture screen in now playing a leading part. The immediate problem is to take totally inexperienced workers and, as quickly as possible, train them for the thousands of welding jobs that wait in factories and plants throughout the country. The part that slidefilms are playing in this educational undertaking is similar to that in many other fields of vocational training, such as aviation mechanics, electricity, metalsmiths and many of the applied sciences.

For this purpose a series of fifteen separate slidefilm subjects has been made available comprising over 800 individual drawings, photos, diagrams and exhibits which cover the entire range of oxyacetylene welding as it is done today.

It is not the purpose of these films to completely train inexperienced workers to the point where they can go to work in the shop. They are designed to give quickly and clearly the beginner a general over-all understanding of the principles of welding, prior to actual shop demonstration and practice. The films visualize welding equipment, explain its purpose, and the fundamental facts about its use. They do this part of the training job with greater speed and clarity than would be possible by lecture or textbook study. This leaves more time for the instructor to follow in the shop itself through on the practical application of the principles pictured.

The power of the picture screen to get across even complex facts and ideas with speed and simplicity has been proved over the years in nearly every phase of vocational training in schools as well as in industry.

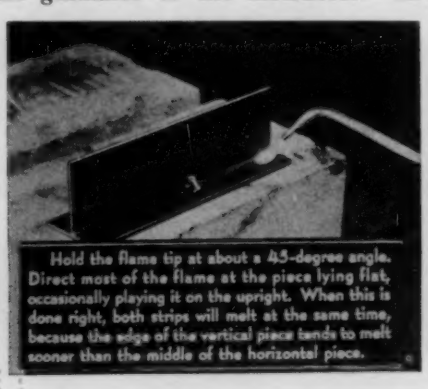
For those not familiar with this type of "discussional" slidefilm, it may be said that it is a strip of reading film, 35-mm. safety motion picture film, with explanatory text, labels, letterings, legends or notations superimposed on the film. The specific purpose of this form of film is to permit the instructor to speak without interference, and to permit the students to talk if desired—supplying illustrated material in illuminated form for class participation, and to encourage discussion. Any ordinary slidefilm projector may be used. Pictures may be thrown up as large as desired. Individual pictures on the strip are arranged in proper sequence, and each film covers one phase of welding only. Each film provides the basis or guide for a single lesson or session. Usually after projecting the film with discussion of the points made, students are taken to the shop and allowed to apply what they have seen and heard in actual practice under the guidance of the instructor. In other words, the fifteen slidefilms in this Kit provide basic material for that many lessons.

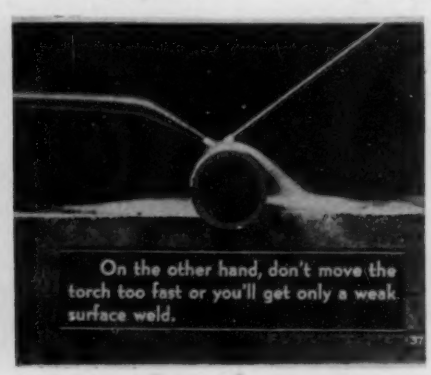
It will be seen that after the showing when the instructor takes his class into the shop each one has a good basic idea of what it is all about, in this way greatly reducing the amount of time required to produce a practical welder.

The series of slidefilms is designed for use in vocational schools, in large metal working plants—in fact, any place where welders are to be trained with maximum speed and thoroughness. They are especially designed to aid the practical welder who has had little or no *teaching* experience, to organize his course, and follow a set lesson "pattern."

Subjects covered in the series are as follows:

1. Introduction to welding
   (Oxyhydrogen and oxyacetylene welding, pressure gages and torches—safety)
2. Setting Up and Lighting the Welding Torch
   (Use of equipment, safety precautions)
3. Welding Flat Ripples
   (Tools, equipment and materials needed)
4. Flat Butt Welds
   (Preparation, procedures, inspecting welds, tests)
5. Fillet Welds—Steel
   (Tools, equipment, materials and preparation)
6. Vertical Welds—Steel
   (Vertical fusion welding, lap welding, fillet welding, cross welding, inspecting)
7. Tube Welds—Steel
   (Specific operations, materials and preparation)
8. Cluster Welds
   (Special tools, preparation and materials, inspection)
9. Oxyacetylene Cutting
   (Cleaning, preparing the cut, preparing cutting torch—safety)
10. Welding Stainless Steel
    (Tools, materials and equipment, definition of characteristics)
11. Brazing and Silver Soldering
    (Definitions, tools, equipment and materials)
12. Welding Aluminum Flat Sheets
    (Characteristics of aluminum, uses of flux, making tack welds, butt weld, lap weld, wandering weld)
13. Welding Aluminum Tubes with Sheets
    (Review of aluminum welding properties, flux, preparation, fillet weld, welding flanges)
14. Fuel and Oil Tank Repairs
    (Preparation, cleaning metals, safety, tack welding, testing)
15. Qualification Test for Welders
    (Test welds, single V-butt, tubular butt, vertical fillet, combination sheet and tube, horizontal fillet, checks and tests)


Hold the flame tip at about a 45-degree angle. Direct most of the flame at the piece lying flat, occasionally playing it on the upright. When this is done right, both strips will melt at the same time, because the edge of the vertical piece tends to melt sooner than the middle of the horizontal piece.



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THE AMERICAN WELDING SOCIETY

ACTIVITIES — RELATED EVENTS

NOMINATING COMMITTEE

With the approval of the Executive Committee the President has appointed the following members to constitute the 1942–43 Nominating Committee:

H. C. Boardman, Chairman, Chicago Bridge & Iron Co., Chicago, Ill.

R. S. Donald, Thomson-Gibb Elec. Welding Co., New York, N. Y.

C. H. Jennings, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

E. A. Kerbey, Midwest Piping & Supply Co., St. Louis, Mo.

A. G. Oehler, Simmons Boardman Pub. Co., New York, N. Y.

W. L. Poole, Air Reduction Sales Co., Birmingham, Ala.

C. W. Roberts, South Western Eng. Co., Los Angeles, Calif.

The By-Laws require that these names be published in the JOURNAL on or before March 1st. The Committee is required to deliver to the Secretary in writing on or before the last Tuesday in May, the names of its nominees for the various elected offices next falling vacant, together with the written acceptance of each nominee.

The purpose of publishing the names of the Nominating Committee in the JOURNAL is to provide every member with an opportunity to make suggestions to the Nominating Committee. To be effective it is essential that these suggestions be sent in at once as, naturally, the Nominating Committee will be required to hold early meetings in order to fulfill its duties as required by the By-Laws.

The offices to be filled are: President, First Vice-President, Second Vice-President, and four directors.

The Directors-at-Large are selected by the Nominating Committee, with due consideration to geographic distribution.

EXECUTIVE COMMITTEE MEETING AMERICAN WELDING SOCIETY

A meeting of the Executive Committee was held in Board Room, A.S.C.E., 29 W. 39th St., New York, N. Y., on Thursday, December 10, 1942. Those present were David Arnott, *Acting President Presiding;* C. A. Adams, A. B. Bagsar, H. C. Boardman, R. W. Clark, W. E. Crawford, E. V. David, J. H. Deppeler, R. S. Donald, E. R. Fish, O. B. J. Fraser, J. D. Gordon, D. S. Jacobus, C. H. Jennings, J. F. Lincoln, H. M. Priest and H. S. Smith.

The following Members of the Board of Directors were present: J. H. Critchett, Isaac Harter and F. L. Plummer.

Others present were W. Spraragen, *Acting Technical Secretary;* and M. M. Kelly, *Secretary.*

Communication from Mr. Hansen, expressing regrets at being unable to perform his duties as president for the next few months because of illness, and requesting Mr. Arnott, first vice-president, to carry on for him during the interim period, was read by Mr. Arnott. Mr. Arnott reported that he had assured Mr. Hansen of his willingness to serve, providing the substitution was satisfactory to the Board of Directors. Mr. Arnott explained that while he is willing to attend to ordinary routine matters connected with the office, he cannot devote time to visiting sections as he is already overburdened with war work. The action of the president in designating the first vice-president to perform the duties connected with the office of President of the SOCIETY in his absence, was confirmed, and the secretary was directed to convey to President Hansen the Committee's warm wishes that he regain his health quickly and completely.

It was reported also that Colonel Jenks had been stricken with pneumonia since the Annual Meeting but was now on the road to recovery. On behalf of the Executive Committee, the secretary was requested to convey to the Colonel the Committee's kind remembrances and best wishes for a quick return to health.

The chairman welcomed the recently elected members, W. E. Crawford, R. S. Donald, C. H. Jennings, H. M. Priest (members of the Executive Committee) and J. H. Critchett and Isaac Harter (members of the Board of Directors).

Committee Appointments

Educational.—It was voted:

That the By-Laws Committee be requested to prepare an amendment of Article VIII, Section 1 (1) so as to broaden the scope of the Educational Committee and to eliminate restrictions in respect to the functions of the Committee.

It was voted further:

That Mr. J. F. Zimmerman be invited to retain the Chairmanship of the Educational Committee and that the personnel of this Committee be composed of the following members, with any additional members acceptable to the Chairman of the Committee: W. J. Conley, J. R. Stitt, P. E. Kyle, W. T. Tiffin, W. F. Hess, A. F. Davis, G. F. Jenks.

Publicity.—it was voted:

That a Publicity Committee, with the following personnel, be appointed for the administrative year commencing October 15, 1942: Ed C. Powers, *Chairman;* L. P. Aurbach, E. J. Del Vecchio, R. S. Donald, T. S. Fetherston, I. S. Ford, T. B. Jefferson, H. J. Kerr, Charles McDonough, J. S. Smith, Merritt L. Smith, W. Spraragen, J. L. Stover, John D. Tebben, G. Van Alstyne and F. T. Van Syckel.

1943 Nominating Committee.—To comply with the By-Laws requirement, that appointment of the Nominating Committee be made by the President through publication in the SOCIETY JOURNAL on or before March 1st, Acting President Arnott offered recommendations for the committee personnel, and upon motion, duly seconded, it was voted:

That the 1943 Nominating Committee be appointed with the following personnel: H. C. Boardman, *Chairman;* R. S. Donald, C. H. Jennings, E. A. Kerbey, A. G. Oehler, W. L. Poole and C. W. Roberts.

Section Officers' Recommendations

It was voted:

To approve recommendation of Section Officers for the adoption of the letter size membership application form.

It was further voted:

To approve recommendation of the section officers for the adoption of the revised draft of standard form of By-Laws for A.W.S. sections prepared by the National By-Laws Committee, dated September 22, 1942.

1942 and 1943 Annual Meetings

It was voted:

To approve recommendation of the Convention Committee that invitation of the A.S.M. to our SOCIETY to participate in the 1943 National Metal Congress and Exposition, the week of October 18, 1943.

Further, it was voted:

That tentative arrangements made by the Convention Committee for housing the 1943 Annual Meeting of the SOCIETY in the Morrison Hotel, Chicago, be approved.

It was the consensus of the meeting that the SOCIETY would be complying with the wishes of government if a shortened, strictly technical meeting for educational purposes, and without entertainment, was held. To that end, it was moved, duly seconded and voted:

That the 1943 Annual Meeting be similar in character to the Annual Meeting held in 1942.

R.W.M.A. Cash Prize Contest

A motion was adopted that the invitation of the R.W.M.A. to our SOCIETY to act as judges of the 1943 R.W.M.A. Cash Prize Contest be accepted; that a committee, with personnel as listed below, be appointed; and that the thanks of the A.W.S. be expressed to the R.W.M.A. for its interest in advancing resistance welding: C. A. Adams, *Chairman;* D. H. Corey, P. E. Kyle, J. W. Meadowcroft and J. D. Tebben.

THE STITCH IN TIME THAT SAVES MONEL WIRE CLOTH

Present equipment with Monel wire cloth units will have to last a long time.

The day will come when they must be patched and repaired—when sections from two or more discarded wire cloths must be joined to make a single serviceable one.

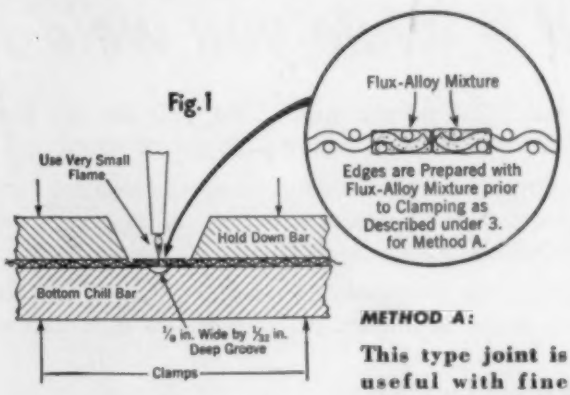
May we recommend that you save the following suggestions for future use if you have no immediate need for them.

★ ★ ★

METHODS OF JOINING MONEL WIRE CLOTH

The soldering or brazing methods used for making wire cloth seams or repairs determine, in many cases, the service life of the cover. The common method of making a joint by lapping and filling with soft solder may result in low joint strength and closing of an unnecessary number of openings. Suggestions on preferred silver brazing methods are given herein.

Fig. 1


Flux-Alloy Mixture
Edges are Prepared with Flux-Alloy Mixture prior to Clamping as Described under 3. for Method A.
Use Very Small Flame
Hold Down Bar
Bottom Chill Bar
1/8 in. Wide by 1/32 in. Deep Groove
Clamps

METHOD A:

This type joint is useful with fine mesh wire cloth (20 mesh or finer) subjected to high stresses or vibration during service. The joint is made in a fixture as shown in Fig. 1. Heavier hold-down bars are used when clamping is not practical. The bars are beveled to facilitate entry of the flame to the joint.

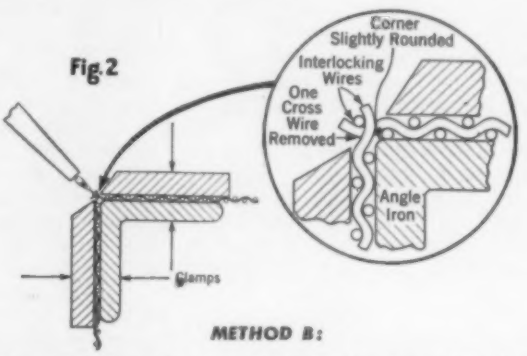
1. The wire cloth edges are cleaned thoroughly to remove oil, grease and corrosion products.

2. The edges of the wire cloth sections to be joined are trimmed carefully to expose a wire running parallel to the joint.

3. Each trimmed edge is set up separately in a jig so that 2 or 3 mesh openings are exposed. This edge is then painted with a mixture consisting of silver brazing flux and a heavy loading of 200 mesh silver brazing alloy filings* (such as "Handy Flux" and "Easy-Flo" filings). The flux-alloy mixture is then fused with a very small flame and the resulting edge filed straight to remove irregularities.

4. The prepared edges of the wire cloth sections are then butted tightly in the fixture and once more painted lightly with the flux-alloy mixture and then fused together with a flame. Care in the use of the torch will insure a minimum number of closed mesh openings.

Fig. 2



METHOD B:

This method produces a joint by brazing wires from one wire cloth section *interlocked* behind the first parallel wire of the other wire cloth section.

1. The wire cloth edges are cleaned thoroughly to remove oil, grease and corrosion products.

2. The edges of both wire cloth sections to be joined are trimmed carefully and one cross wire parallel to the edge of one wire cloth is removed to permit interlocking and clamping.

3. Flux and silver brazing alloy is applied and the brazing completed in one pass.

4. Removed from the fixture, the joint is flattened and the remaining small ridge eliminated by hammering lightly with a wooden mallet, using a smooth hard wood block as a dolly.

• • •

For full information on joining Monel, write for Bulletin T-2, "Welding, Brazing and Soft Soldering of Monel, Nickel, and Inconel."

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street **New York, N. Y.**

**Filings are procurable through the producers of silver brazing products.*

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MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • NICKEL • "Z" NICKEL

Sheet . . . Strip . . . Rod . . . Tubing . . . Wire . . . Castings

Outline of Work Committee Recommendations

The following recommendations of his committee were reported by Chairman Clark and actions taken thereon are recorded below:

Withdrawal of Representation on American Coordinating Committee on Corrosion.—On advice of representative Dr. Maxwell, that A.W.S. representation on this committee was not beneficial to the A.W.S., the Committee on Outline of Work, after due consideration, recommended withdrawal of representation. Accordingly, it was, upon motion, duly seconded and voted:

That recommendation of the Outline of Work Committee for the withdrawal of representation on the American Coordinating Committee on Corrosion be sustained and the American Coordinating Committee on Corrosion be so notified.

Committees Discharged.—Committee on Recommended Practices for Fusion Welding High-Alloy Steels: In view of the fact that the majority of the committee members voted that the committee be discharged, the Committee on Outline of Work recommended that the wishes of that committee be carried out.

Committee on Weldability Tests for Steel: Because of the inability of the Chairman of this committee to give the necessary time to the work and the fact that the work of the two subcommittees can come under the Committee on Standard Tests for Welds, the Committee on Outline of Work recommended the discharge of this committee and the transfer of its two subcommittees to the Committee on Standard Tests for Welds. Upon motion duly seconded, it was voted:

To approve recommendations of the Outline of Work Committee for the discharge of the Committee on Recommended Practices for Fusion Welding High-Alloy Steels, and of Committee on Weldability Tests for Steel, and for the transfer of the two subcommittees of the last-mentioned committee to the Committee on Standard Tests for Welds.

Replacement of Technical Secretary for the Duration of the War.—It was reported that since the last meeting, our Technical Secretary had joined the armed forces and the Committee on Outline of Work was called upon to give consideration to his replacement for the duration. In view of Mr. Spraragen's inability to take on this assignment, because of demands on his time in connection with the editing of THE WELDING JOURNAL and the Secretaryship of the Welding Research Committee, it was believed that the best arrangement was the full-time employment of a young man with draft deferment, supplemented in the beginning by the services of an older man with the necessary background and familiarity with the technical activities of the A.W.S. to act as a consultant and guide to the young man.

It was voted:

That recommendation of the Outline of Work Committee for the engagement of Mr. Obert as Acting Technical Secretary of the SOCIETY on a part-time consulting basis and the employment of Mr. Simon Greenberg as Assistant Technical Secretary, for the duration of the war, if found satisfactory, be approved.

Finances

In submitting report of financial operations for the year ended September 30, 1942, and budget recommended by the Finance Committee for the ensuing year, the Treasurer made special reference to the following:

Annual Report on Finances for the Year Ended September 30, 1942.—He drew attention to: improvement in the SOCIETY's net worth; the writing down of office equipment to a nominal value of $1, transfer of $7000 to the Permanent Funds Reserve Account; and the excess of income over expenses for the year amounting to $8491.79, largely due to the increase in actual dues collections, the code, bulletin and metallurgy book sales, and to JOURNAL advertising.

Improvement in the Permanent Funds Reserve brought about by the transfer of 1% of the SOCIETY's gross income for the past year, transfer of the $7000 mentioned in paragraph above, and the transfer of the six St. Louis and San Francisco Bonds to the Permanent Funds Reserve Account, plus the interest collections on the bonds

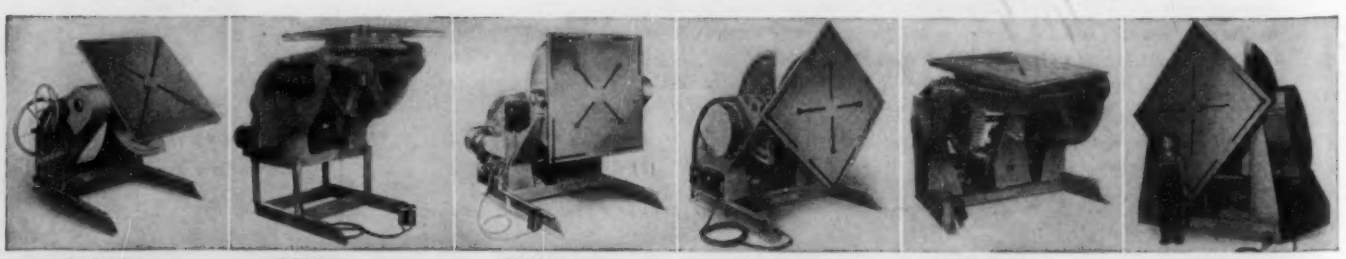
We'll hold it while you weld it...

If you're doing a welding job on war production, you can get Ransome Positioners to help you increase your output and reduce costs.

With this modern equipment, your welders can readily swing the heaviest and most complicated pieces for a downhand position on every pass . . . top, sides, and bottom, with one set-up.

Made in a complete range of types and sizes . . . hand-operated and motor-operated . . . up to 20-ton capacity . . . there's a unit that will fit your needs exactly.

● *Write for literature showing how Ransome Positioners can solve some of your major welding problems.*



Light-duty, hand-operated | 2500-lb. cap., elevating base | 3000-lb. cap. | 3-ton cap. | 8-ton cap. | 20-ton cap.

Ransome WELDING POSITIONERS

INDUSTRIAL DIVISION • RANSOME MACHINERY COMPANY • DUNELLEN, NEW JERSEY

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Ampco-Trode is made in six grades and six sizes—$\frac{1}{8}$" to $\frac{1}{2}$". It is suitable for metallic arc, carbon arc and oxy-acetylene welding.

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AMPCO METAL, INC.

Department WJ-2 Milwaukee, Wisconsin

Improvement in Society's Resources as shown in comparative statement for years ended September 30, 1942 and 1941.

Consideration was given to the recommendations of the Finance Committee and the following actions were taken thereon:

Voted: That financial statement audited by David Joseph & Co., public accountants, covering fiscal year ended September 30, 1942, be accepted;

That budget for the fiscal year commencing October 1, 1942, recommended by the Finance Committee be approved.

Welding Journal Advertising Rates

The Publication Committee Chairman reported that his committee had considered favorably an increase in THE WELDING JOURNAL advertising rates, effective April 1, 1943, for new advertisers and April 1, 1944, for those now advertising in the JOURNAL. It was pointed out that the present rates became effective in May 1938. Since that time, the JOURNAL's circulation has increased considerably and is today at 7500 copies minimum. The rates proposed are as follows:

	One Time	3 Times	6 Times	12 Times
1 Page	$120	$105	$ 95	$ 85
1/2 Page	70	60	55	50
1/4 Page	42	38	35	30
1/8 Page	30	25	20	18
1 Page Preferred Position	135	120	110	100
Covers	4th Cover	2nd Cover	3rd Cover	
12 time contracts	$160	$130	$125	

It was voted:

To approve THE WELDING JOURNAL advertising rates recommended by the Publications Committee.

LICKING THE AMERICAN ACCIDENT PLAGUE

The National Safety Council is making progress tracking down the specter of manpower losses through accidental death and injury hanging over war production lines. Latest and biggest counter move in what is shaping up as a national safety movement is a grass-roots drive on accidents planned for 14 major war-production centers.

For the past several months the Council has been feeling out the national accident situation. A network of liaison with Government agencies, with private industry and over a hundred private organizations has been set up. And now, with the decks cleared for action, and armed by voluntary contributions through the War Production Fund to Conserve Manpower, the National Safety Council is in a position to go to town in a big way.

William A. Irvin, national chairman of the Fund and former steel executive who has emerged as the nation's spokesman for safety in America, will visit areas hampered by accidents in turning out the tools of war with maximum efficiency. He will be accompanied by Colonel John Stilwell, president of the National Safety Council, and other representatives of that organization.

Local safety leadership will be enlisted among businessmen, industrialists, union heads and the municipal authorities in each center visited. Each city will be offered the full aid of the National Safety Council in curbing its accident toll. The aim is to make a double-barreled attack on accidents. The Council will serve as consultant and over-all coordinator. The community will organize and get to work to route out accidents on the spot where they occur.

"To lick the accident problem there must be centralized leadership with complete technical resources," Mr. Irvin explains. "This leadership will be provided by the National Safety Council—the general staff in our campaign. At the same time there must be combat troops, led by men who know the terrain. Here local leadership comes in."

The five weeks' swing around the country is scheduled to begin January 17th from New York. It will include stops at St. Louis, Chicago, Minneapolis, St. Paul, Seattle, Portland, San Francisco, Los Angeles, San Diego, Dallas, Ft. Worth, Houston, New Orleans and another city to be designated.

In cities where there are local safety councils, they will be asked to enlist as charter members in the National Safety Council's revised wartime organization.

ARE YOU HAVING REJECTIONS FROM SPOT WELD BURNS?

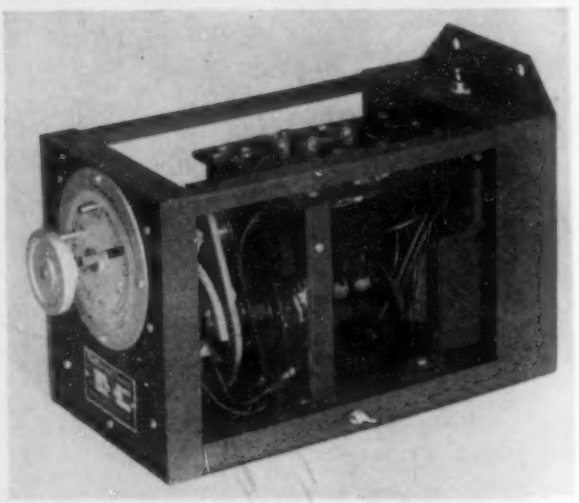
ARE YOU TROUBLED FROM TOO MUCH HEAT?

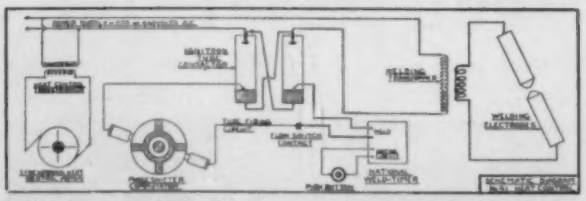
NATIONAL HEAT CONTROL UNITS PROVIDE FINGER-TIP, INSTANTANEOUS CHANGE OF TRANSFORMER HEAT IN 45 GRADUAL INTERMEDIATE STEPS, BETWEEN EACH PRIMARY TAP.

"Number 2 Tap is Too Low, but Number 3 Tap is Too Hot," complains the Operator.

TRY HEAT CONTROL for the Ideal Setting, and Compensate for Voltage Variations Too. Make Clean, Uniform Welds, Minimize Spitting, and Eliminate Secondary Grinding Operations.

DO IT THE NATIONAL WAY, WITH IGNITRON CONTACTORS, AND MODEL 41 HEAT CONTROL.





Schematic wiring diagram showing the hook-up of Heat Control in a Welding machine set-up.

Model 41 Heat Control, illustrated here, is an ingenious, yet simple Control, that synchronously rotates a copper cross shaped segment between two brushes, which are connected in series with the Ignitron tube firing circuit. Brushes are positionable, and in moving same, produce Phase Shifting, or in simple terms, crop off any desired amount of the current feeding the welding transformer, reducing the Heat from maximum down to substantial zero.

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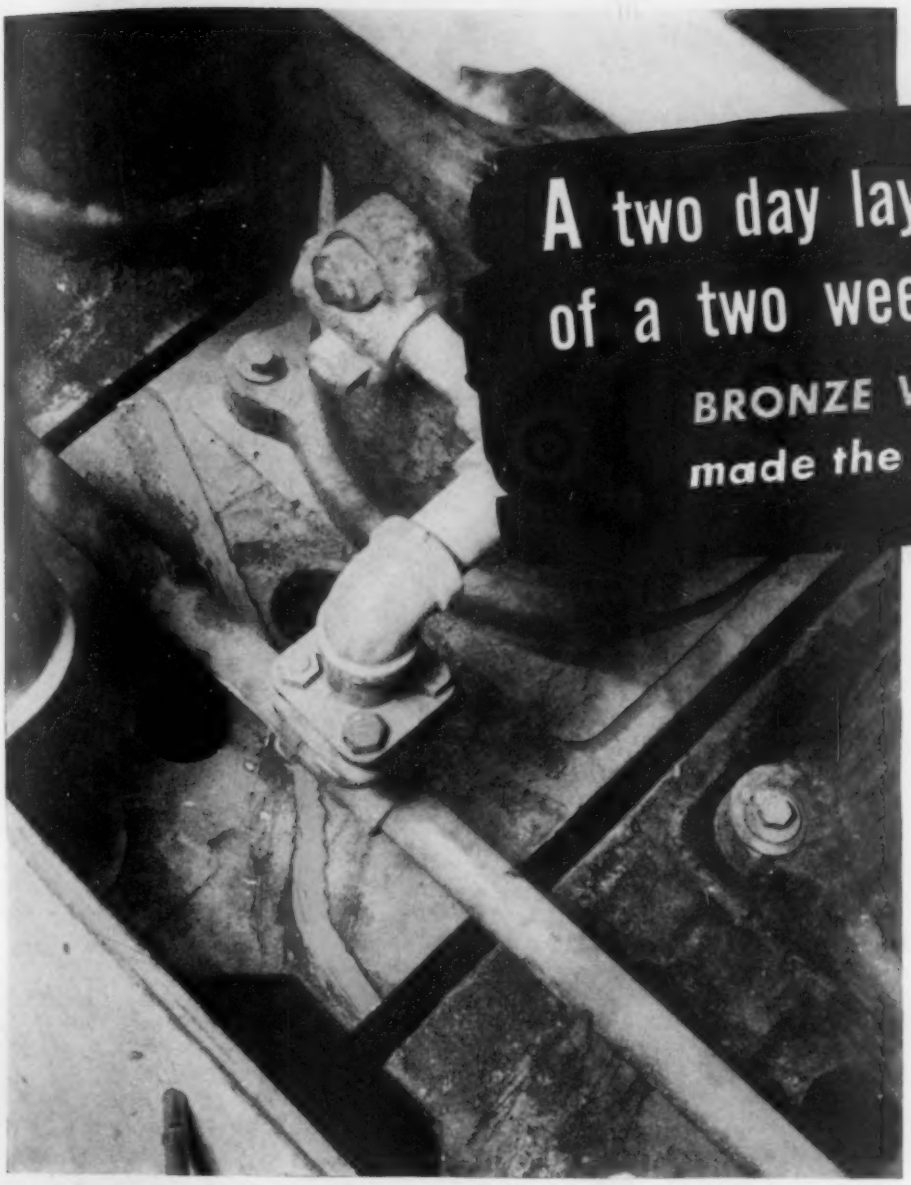

This bronze repair weld on a 2½-ton bolster has no trouble standing up under 2,000 pounds per square inch hydraulic pressure. Picture from The B. F. Goodrich Company.

When this 2½-ton bolster on a belt packing press cracked in a B. F. Goodrich plant, the press was "down", and vital war production had to wait. But as has happened so often in industry, bronze repair welding cut the time loss to the bone . . . in this case to two days. It would have taken two weeks to get a new casting.

After 32 hours of work and the use of 125 pounds of Tobin Bronze* Welding Rod, the press was back at work . . . the repair weld successfully withstanding the 2,000 pounds per square inch pressure exerted hydraulically on the bolster.

For speedy, wartime emergency repair welding, you just can't beat Anaconda bronze. Anaconda 997 Low-Fuming and Tobin Bronze, among others, meet every requirement for efficient, durable repair welding. For complete information, write for the new edition of Anaconda Publication B-13. 4382

*Reg. U. S. Pat. Off.

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This will provide a permanent framework for a nation-community plan of action. Where no local safety council exists, committees are to be organized which in time can develop into full-fledged safety councils in their own right.

JOHN FARRELL METTEN TO HEAD SOCIETY OF NAVAL ARCHITECTS

John Farrell Metten, vice-chairman of the New York Shipbuilding Corporation and formerly president of that company in Camden, N. J., was elected president of The Society of Naval Architects and Marine Engineers at the Society's Fiftieth Annual Meeting which closed its two-day session tonight at the Waldorf-Astoria Hotel, New York. Mr. Metten succeeds Rear Admiral Emory S. Land, Chairman of the War Shipping Administration and the United States Maritime Commission, who has served as president of the Society for the past two years.

Mr. Metten was born in Kent County, Del., on December 15, 1873, and received his early education in district schools and at Middletown Academy. He was the recipient of the honorary degree of Doctor of Engineering from Lehigh University in 1928. He started his career as a machinist apprentice, later becoming a machinist and draftsman at the Newport News Shipbuilding and Dry Dock Company Newport News, Va. Later he was successively chief draftsman, chief engineer and vice-president of the old William Cramp and Sons Ship and Engine Building Company, Philadelphia, Pa. Selected by the navy and private shipyards to undertake the first standardization of design for naval construction, he became president of the Marine Engineering Corporation, Philadelphia, Pa., where he actively directed the design of the six Pensacola class cruisers. Upon completion of this work he became vice-president of the New York Shipbuilding Corporation in full charge of hull and machinery design. Mr. Metten holds numerous active patents on turbine design, propulsion machinery and auxiliaries. In 1940 Mr. Metten was awarded the David W. Taylor gold medal, the highest award of The Society of Naval Architects and Marine Engineers. Mr. Metten will take over his new duties on January 1.

OXY-ACETYLENE WELDING AND CUTTING

Oxy-Acetylene Welding and Cutting, by J. W. Giachino, the latest, up-to-date, illustrated handbook on gas welding and cutting has been especially prepared to show step-by-step details of general and specialty work. Includes illustrated instructions on the welding of aluminum alloys and 18–8 chromium steels, in addition to thorough coverage of equipment and methods involved in regular plate and tube welds.

Each job is explained with direct application to everyday problems of construction and repair. Useful to every welder or student of welding not only for its information on many subjects but for such active features as charts on metal identification; the official qualification test for U. S. aircraft welders, including illustrated practice welds for the test (see the chapter on "Airplane Welding"); a complete reprint of official Association rules for preventing welding and cutting fires; and a reprint of the official regulations for gas systems.

The author is stationed at one of the best-equipped industrial training schools in the country. He is the author of three other successful books on metalwork and, incidentally, holds his civilian pilot's license and Government instructor's rating in aircraft construction.

Price $2.50, 196 pages, Manual Arts Press, Peoria, Ill.

COMMUNICATION TO THE EDITOR

THE JAMES F. LINCOLN ARC WELDING FOUNDATION

CLEVELAND, OHIO, U.S.A.

December 24, 1942

DEAR MR. SPRAGUEN:

The response from the colleges to our announcement of the $6750 Annual Engineering Undergraduate Award and Scholarship Program has been cooperative and commendatory. There are, however, a few responses which indicate that in cer-

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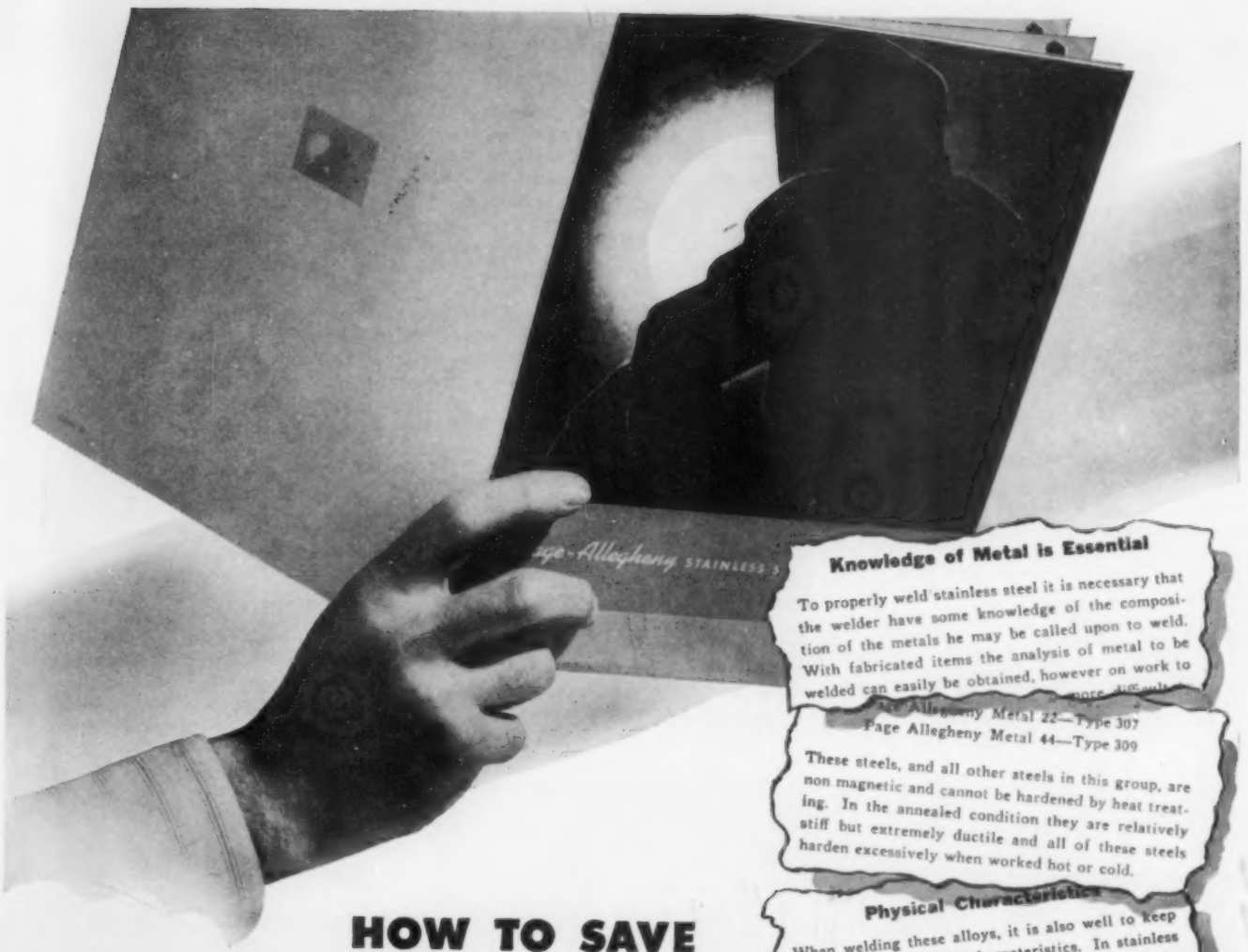


HOW TO SAVE TIME AND MATERIAL WELDING *Stainless Steel*

★ This booklet will help you. You can get a copy by asking your local PAGE Distributor or writing us direct at the mill in Monessen.

It gives needed data on 42 Commercial Stainless Steels—analyses; physical characteristics; reaction to heat and to cold working; specific welding electrodes to use with each; correct amperage and voltage; polarity; length of arc; direction of arc; starting the weld; preventing undercutting, etc., etc.

A copy of this well illustrated booklet will be sent gladly as soon as your request is received.

Knowledge of Metal is Essential

To properly weld stainless steel it is necessary that the welder have some knowledge of the composition of the metals he may be called upon to weld. With fabricated items the analysis of metal to be welded can easily be obtained, however on work to

Page Allegheny Metal 22—Type 307
Page Allegheny Metal 44—Type 309

These steels, and all other steels in this group, are non magnetic and cannot be hardened by heat treating. In the annealed condition they are relatively stiff but extremely ductile and all of these steels harden excessively when worked hot or cold.

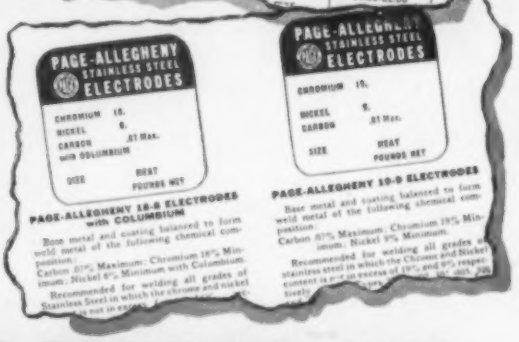
Physical Characteristics

When welding these alloys, it is also well to keep in mind their physical characteristics. In stainless steels, the coefficient of expansion is high and the heat conductivity is low, therefore, when setting up a job for welding these factors must be taken into account and allowance made for expansion and con-

STANDARD GRADES

The following list shows standard grades of stainless steels. Those which are not included in the standard classifi on special order.

GRADE	TYPE NO.	CARBON	CHROME
Allegheny 17-7	301X	.10-.20	16.00-18.00
Allegheny "C"	302	Over .08-.20	17.00-19.00
Allegheny Metal F.M.*	302B	Over .08-.20	17.00-19.00
	303	.20 max.	17.00-19.00
Allegheny "A"	304	.11 max.	17.00-19.00
Allegheny "B"	305	Over .08-.20	18.00-20.00
Allegheny "B" Spec.	306	.11 max.	18.00-20.00
Allegheny 77		Over .08-.20	19.00-22.00



PAGE WELDING ELECTRODES

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tain instances it is assumed that student contestants must have had some previous connection with welding, either practical or academic, in their course of study. This misunderstanding is evident by such phrases as "although welding does not come under this department," and "your announcement is being referred to the Welding Department of our shops."

The Program is open to all students of engineering in *all* departments and the emphasis of the program is "Design for Arc Welding" and not on the technique of welding. Many managers and engineers in industry are effecting economies of labor and material and improving designs without themselves being adept in the technique of welding. It is the aim of the Foundation in the present student program to prepare student engineers for this same activity in their active professional work to come in the future.

It would be unfortunate if students in some areas were deprived of the opportunity of participating in this program on the mistaken impression that a technical knowledge of arc welding is necessary. The necessary background can be acquired by any student in a very few hours of reading.

Cordially yours,
A. F. DAVIS, *Secretary*

CURTISS-WRIGHT TRAINS WOMEN FOR ATOMIC HYDROGEN WELDING

To help produce Curtiss electric propellers for the fighting and bombing planes of the United Nations, women are being trained in the technique of atomic hydrogen arc welding at the Pennsylvania plant of the Propeller Division of Curtiss-Wright Corporation. The first graduate of this plant's welding school recently completed her training in 59 days and has now taken her place beside men welding operators. She will soon be joined by thirteen other women now learning the technique of welding under competent instruction at this school.

Atomic hydrogen welding, developed by General Electric some years back, is used at this propeller plant to join together the camber and thrust plates of propeller blades.

The illustration shows a group of student women operators at work in the welding school of the Pennsylvania plant, Curtiss-Wright Corp., Propeller Division, with their instructor in the background. They are seated before the learning tables where they are taught the technique of atomic hydrogen arc welding of Curtiss electric propellers before they advance to the welding jigs for actual work on the propeller blades.

EDELSON JOINS INDUCTION HEATING CORP.

Leo Edelson, for the past 10 years Development Engineer for Handy & Harman, has joined the Induction Heating Corp. as Executive Vice-President.

ROMANN JOINS WAR METALLURGY COMMITTEE

Mr. John H. Romann, chief metallurgist of Tube Turns, Louisville, Ky., manufacturers of welding fittings and special

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Swift Electric Welder Company, Detroit, Mich.
Taylor-Hall Welding Corporation, Worcester, Mass.
Taylor-Winfield Corporation, Warren, Ohio
Thomson-Gibb Electric Welding Co., Lynn, Mass.
Welding Machines Mfg. Company, Detroit, Mich.
Acme Electric Welder Co., Los Angeles, Calif.
Eisler Engineering Company, Newark, N. J.
Expert Welding Machine Company, Detroit, Mich.
Sciaky Bros., Chicago, Ill.

ASSOCIATE MEMBER COMPANIES

Welding Sales and Engineering Co., Detroit, Mich.
P. R. Mallory and Co., Indianapolis, Ind.
S-M-S Corporation, Detroit, Mich.
Electroloy, Inc., New York, N. Y.

RESISTANCE WELDER MANUFACTURERS' ASSOCIATION
505 ARCH STREET PHILADELPHIA, PA.

forgings, was recently honored by being appointed chairman of a committee to conduct a special nation-wide investigation in industrial plants concerning the low-temperature properties of metals.

This research is being carried on for the War Department by the War Metallurgy Committee of the National Research Council, National Academy of Sciences, Washington, D. C.

According to Mr. Clyde Williams, head of the War Metallurgy Committee, Mr. Romann has been granted an indefinite leave of absence from Tube Turns in order to direct this work.

The War Metallurgy Committee supervises research for several branches of the government, including the War Department. It reports to the Office of Scientific Research and Development, an independent agency created by the President of the United States.

WELDED SHIP THAT REFUSED TO SINK AFTER TORPEDOING NOW REBUILT AND BACK IN SERVICE

The accompanying illustration, provided by courtesy of The Lincoln Electric Company of Cleveland, is another testimonial to arc welding in ship construction.

This is a photo of the 12,500-ton tanker, *Victoria*, which was torpedoed twice on her trip from Argentina to New York last spring, but managed to complete the voyage.

Displaying the neutral flag of Argentina, this tanker, laden with linseed oil, was 300 miles off Cape Hatteras when a torpedo hit her 30 feet aft amidships. Although the deck plate buckled, her all-welded hull stood, and the bulkheads and tanks were unbreached. Captain Felix G. D. Salomone, the master, proceeded, but 50 minutes later another torpedo smashed into portside. The captain and 39 of the unhurt crew pulled off, but were embarrassed two nights and a day later when a U. S. warship picked them up and informed them that the torpedoed vessel was still afloat.

The ship arrived into New York Harbor under her own power and was laid up for repairs, but she is on the go again.

Cargill, Incorporated of Albany, N. Y., constructed the vessel. It was pointed out that the welded construction was responsible in keeping the tanks and the bulkheading from breaking open.

HARDNESS OF TIN-BASE ALLOYS

Methods of obtaining new and stronger tin-base alloys suitable for use as bearing metals is part of the program of research conducted by the Tin Research Institute.

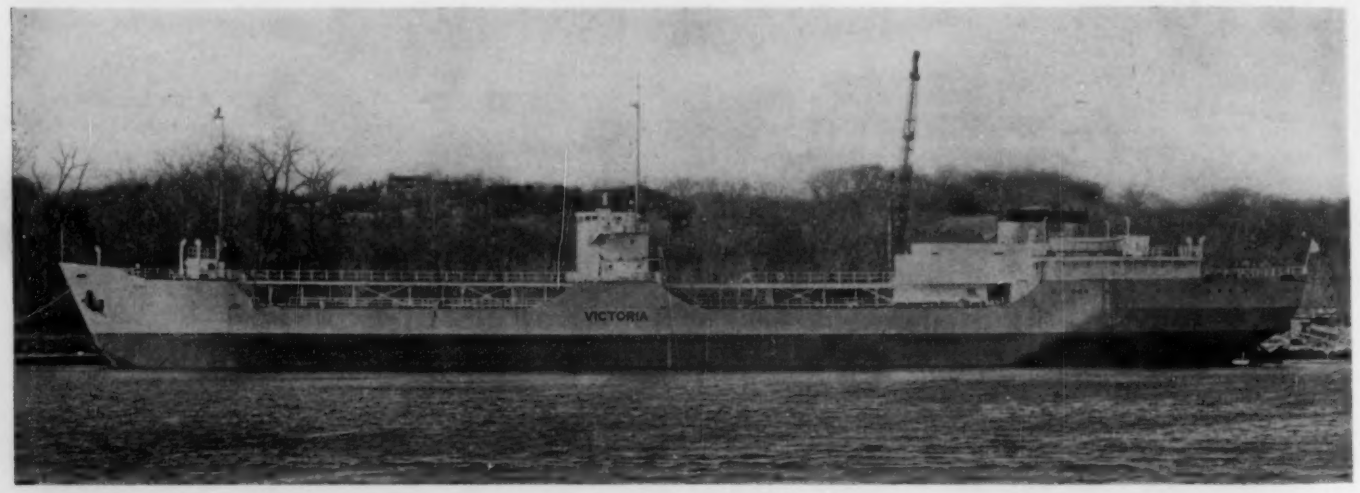
The effect on hardness, produced by quenching from the highest practicable temperature followed by prolonged tempering at 100° and 140° C., has been examined for 80 tin-base alloys containing 4 to 14% antimony and 0 to 10% cadmium. The results of the hardness tests are recorded in a paper by W. T. Pell-Walpole, B.Sc., Ph.D., in the *Journal of the Institute of Metals*, Vol. 68, October 1942.

It is shown that these alloys can be hardened by heat treatment and maintain a useful degree of improvement for at least 1000 hr. at 100 to 140° C. The best alloys in this respect are those in the range antimony 9 to 10%, cadmium 1 to 1½%, balance tin. The degree of improvement is indicated by Vickers diamond pyramid hardness tests. Values of 33 to 34 are obtained, compared with values of 26 to 30 in the normal non-heat-treated condition.

Reprints of this paper may be obtained, free of charge, from the Tin Research Institute, Fraser Road, Greenford, Middlesex.

PACIFIC COAST'S FIRST ELECTRODE PLANT

The new electrode plant of National Cylinder Gas Company (Pacific Coast) is now in production. The strong industrial position of the Pacific Coast area has been stimulated to such a great extent by war production that the supplying of welding electrodes became a serious problem. To meet this demand, National, in cooperation with the Navy Department, put this first electrode plant for the Pacific Coast into operation in the short period of three months. Millions of pounds of



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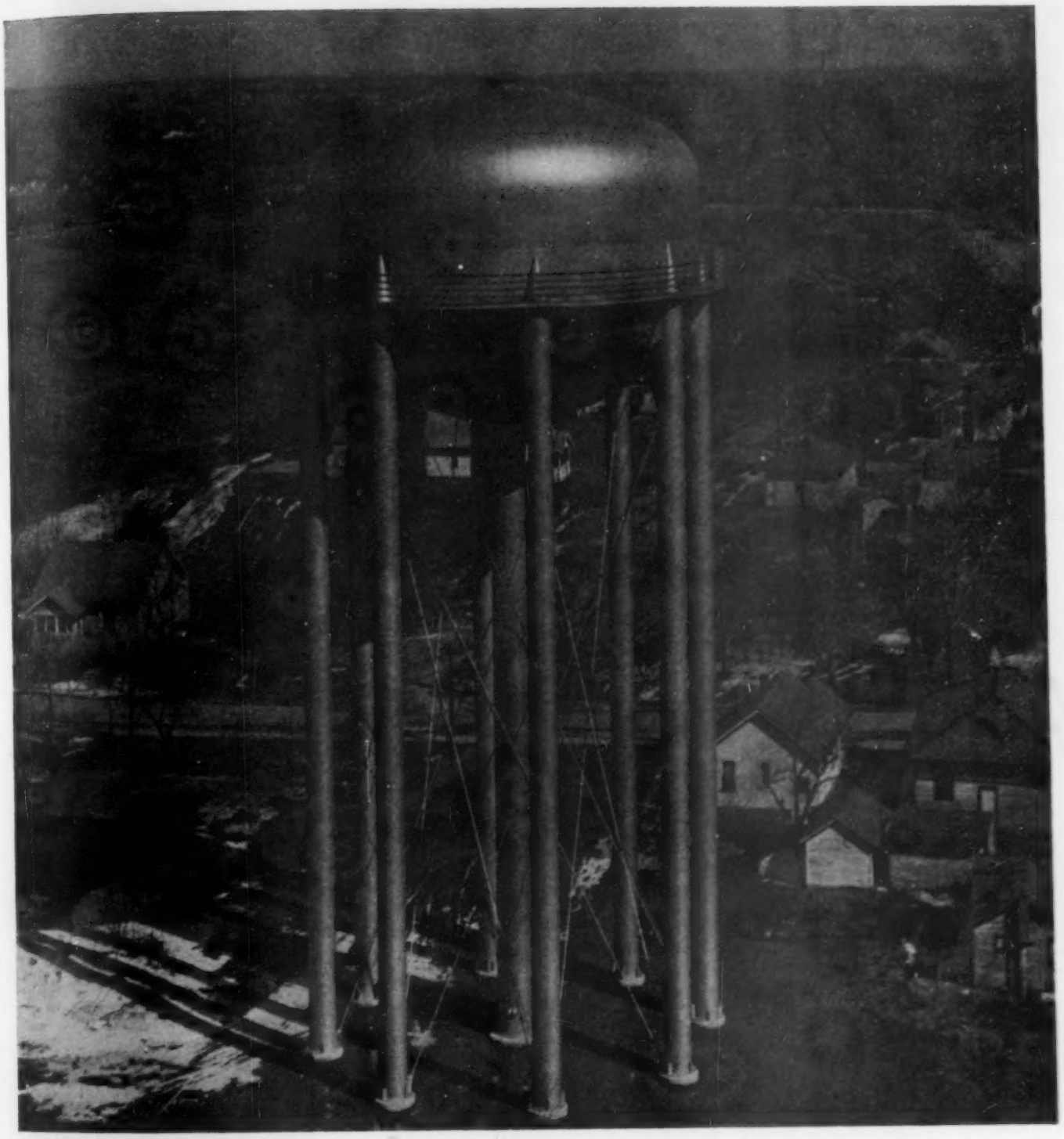
ANTI-BORAX COMPOUND COMPANY
Fort Wayne, Indiana



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Fabricating plants in CHICAGO, BIRMINGHAM and GREENVILLE, PA.

"Sureweld" protected-arc electrodes have already been produced there, with the entire output going to industries essential to the war effort.

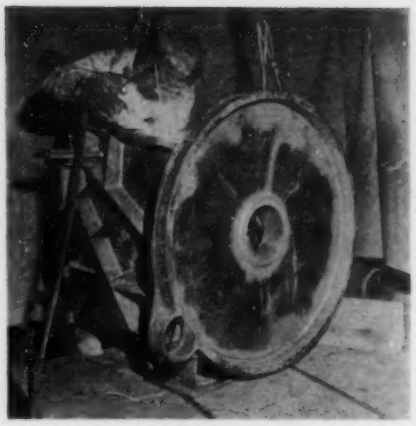
The most up-to-date production machines and methods are used at the new plant to assure maximum output and to maintain the high quality standard inherent to "Sureweld" electrodes.

The new California electrode plant is the third which National Cylinder Gas Company has in operation—the others are located in the Midwest and Canada.

The Pacific Coast Sales Offices of National Cylinder Gas Company are located at 4950 Sante Fe Ave., Los Angeles, Calif., and 326 Howard St., San Francisco, Calif.

COOPER JOINS W.P.B.

Mr. J. H. Cooper has been appointed Chief of the Resistance Welding Section, General Industrial Equipment Division, War Production Board, Washington. He has been given an indefinite leave of absence by The Taylor-Winfield Corporation, with whom he has been associated for the last six years as Welding Engineer. Prior to this he spent nine years with the General Electric Company, where he specialized in arc welding. Mr. Cooper is a graduate of the University of Missouri and Union College, where he obtained his B.S. and M.S. degrees. He is a member of the AMERICAN WELDING SOCIETY and Association of Iron and Steel Engineers.



OEM Photo by Palmer

MAKING THE SPARKS FLY

The welding machine glows brightly as a worker in a government arsenal attacks a fabricated structure for the 90 mm. gun anti-aircraft carriage.

COMMUNICATION TO THE EDITOR

December 31, 1942

To the Secretaries of Cooperating Organizations on the Sectional Committee on a Code for Pressure Piping, B31

Revision, American Standard Code for Pressure Piping, B31

Gentlemen:

Copies of the revision of the American Standard Code for Pressure Piping, B31.1-1942, have just been received from the printer and since your organization is represented on the sectional committee which developed this American Standard, it gives me pleasure to send you a complimentary copy under separate cover.

The American Society of Mechanical Engineers, the sponsor for this project, greatly appreciates the time and effort which your representative has given to the development of this American Standard during the past five years and to request that your organization continue to foster this project by assisting in bringing about its general acceptance by industry.

We all realize that one of the most important phases of the standardization movement in this country is the putting of American Standards into practice. To this end we earnestly request that your organization take an active part in the promulgation of the revision of the American Standard Code for Pressure Piping by indicating to your members the advantages resulting from its general use.

A concerted effort of this kind will do much to bring about general acceptance of this code in the development of which your organization has had a part.

Very truly yours,

C. B. LEPAGE

Assistant Secretary, A.S.M.E.

EDITOR'S NOTE: Sections on welding will be reproduced in the March issue of THE WELDING JOURNAL.

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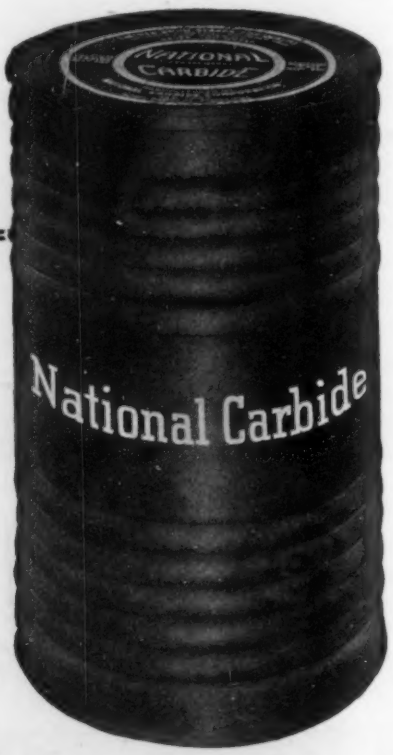

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CHAIRMAN—C. C. PINCKNEY, Birmingham Boiler & Eng. Co., 41st St. & 8th Ave., North, Birmingham, Ala.
SECRETARY-TREASURER—W. L. POOLE, Air Reduction Sales Co., 2825 N. 29th Ave., Birmingham, Ala.

BOSTON 2nd Mon.
CHAIRMAN—P. L. F. FEYLING, 140 Gilbert Rd., Belmont, Mass.
SECRETARY—P. N. RUGG, 22 Eastern Ave., Wakefield, Mass.

CANAL ZONE 1st Tues.
CHAIRMAN—CLIFFORD B. JONES, Box 533, Diablo Heights, Canal Zone
SECRETARY—R. E. HOLLICK, Box 924, Diablo Heights, Canal Zone

CHATTANOOGA, TENN. 1st Wed.
CHAIRMAN—ROY E. LORENTZ, Combustion Engineering Co., Chattanooga, Tenn.
SECRETARY-TREAS.—A. R. McLAIN, 14 S. Brooks Ave., Chattanooga, Tenn.

CHICAGO 3rd Fri.
CHAIRMAN—ERIC R. SEABLOOM, Crane Co., 836 S. Michigan Ave., Chicago, Ill.
SECRETARY—T. B. JEFFERSON, *The Welding Engineer*, 506 S. Wabash Ave., Chicago, Ill.

CINCINNATI, OHIO
CHAIRMAN—R. L. KIRBY, R.F.D. No. 1, Box 131, Sharonville, Ohio
SECRETARY—GEO. A. JACOBY, 1743 S. Derexa Drive, Hamilton, Ohio

CLEVELAND 2nd Wed.
CHAIRMAN—R. J. KRIZ, James Herron Co., 1360 W. 3rd St., Cleveland, Ohio
SECRETARY-TREAS.—A. LESLIE PFEIL, Universal Power Corp., Cleveland, Ohio

COLORADO 3rd Wed.
CHAIRMAN—J. H. JOHNSON, Johnson Supply Co., Denver, Colo.

COLUMBUS, OHIO 2nd Fri.
CHAIRMAN—CLAY W. ROBERTS, Pennsylvania R. R., Columbus, Ohio
SECRETARY—G. S. HERREN, The Seagrave Corp., Columbus, Ohio

CONNECTICUT 1st Tues.
CHAIRMAN—B. H. PERRY, Bigelow-Sanford Carpet Co., Thompsonville, Conn.
SECRETARY—J. IMPERATI, American Brass Co., Ansonia, Conn.

DETROIT 1st Fri.
CHAIRMAN—O. L. SMITH, Weldit Acetylene Co., 638 Bagley Ave., Detroit, Mich.
SECRETARY—G. N. SIEGER, S-M-S Corp., 1165 Harper Ave., Detroit, Mich.

GEORGIA 1st Fri.
CHAIRMAN—RALEIGH DRENNON, 357 W. Peachtree St., N. E., Atlanta, Ga.
SECRETARY—EDWARD GUILLOTT, 282 Spring St., N. W., Atlanta, Ga.

HAWAII Last Thurs.
CHAIRMAN—GEORGE GLOVER, W. A. Ramsay, Ltd., Honolulu, T. H.
SECRETARY—ALAN G. SLIPPER, Hawaiian Gas Products Co., P. O. Box 2454, Honolulu, T. H.

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CHAIRMAN—E. F. GILYEAT, J. D. Adams Mfg. Co., Indianapolis, Ind.
SECRETARY—H. D. WEED, P. R. Mallory & Co., Indianapolis, Ind.

KANSAS CITY, MO. 1st Tues.
CHAIRMAN—WM. S. FARR, Air Reduction Co., Kansas City, Mo.
SECRETARY—EDGAR H. FINLAY, Finlay Engineering College, 1001 Indiana Ave., Kansas City, Mo.

LAKE SHORE
CHAIRMAN—FRED HERBST, JR., McMullen & Pitz Construction Co., 923 Commercial St., Manitowoc, Wis.

LOS ANGELES 3rd Thurs.
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SECRETARY—E. O. WILLIAMS, Victor Equipment Co., Los Angeles, Calif.

LOUISIANA 1st Fri.
CHAIRMAN—G. O. HUET, Higgins Industries, Inc., 1755 St. Charles Ave., New Orleans, La.
SECRETARY—A. E. ABAUNZA, Gulf Engineering Co., 916 Peters St., New Orleans, La.

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CHAIRMAN—A. R. WYNN, 913 N. Hill Rd., Baltimore, Md.
SECRETARY—VAN RENSSELAER P. SAXE, 100 W. Monument St., Baltimore, Md.

MILWAUKEE 3rd Fri.
CHAIRMAN—KEITH WALKER, 3721 S. Herman St., Milwaukee, Wis.
SECRETARY—GILBERT F. MEYER, Machinery & Welder Corp., Milwaukee, Wis.

NEW YORK 2nd Tues, except when Joint Meeting is held
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SECRETARY—GEORGE SYKES, The Linde Air Products Co., General Publicity Dept., 30 E. 42nd St., New York, N. Y.

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CHAIRMAN—C. E. COMFORT, St. Paul Structural Steel Co., 162 York Ave., St. Paul, Minn.
SECRETARY—ALEXIS CASWELL, Manufacturers' Assoc. of Minn., 200 Builders Exchange Bldg., Minneapolis, Minn.

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CHAIRMAN—T. B. SMITH, Federal Shipbuilding and Drydock Co., Kearny, N. J.
SECRETARY—W. H. HART, Chas. W. Krieg Co., 52-60 Dickerson St., Newark, N. J.

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SECRETARY—R. S. PELTON, General Electric Co., Schenectady, N. Y.

OKLAHOMA CITY First Thurs.
CHAIRMAN—FRANCIS SPREHE, Midwest Steel Co., 2 N. Indiana Ave., Oklahoma City, Okla.
SECRETARY—HOWARD N. SIMMS, Box 1714, Oklahoma City, Okla.

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CHAIRMAN—B. L. FUCHS, Fuchs Machinery & Supply Co., 15th & Jackson Sts., Omaha, Neb.
SECRETARY—GEORGE A. THRAPP, The Baldach Co., 1201 California St., Omaha, Neb.

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SECRETARY—PHIL SOMMER, 207 N. Bourland Ave., Peoria, Ill.

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CHAIRMAN—H. W. PIERCE, New York Shipbuilding Corp., Camden, N. J.
SECRETARY—H. CAREY BOSS, 248 Rhoads Ave., Haddonfield, N. J.

PITTSBURGH Middle Wed.
CHAIRMAN—F. H. DILL, American Bridge Co., Ambridge, Pa.
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SECRETARY-TREAS.—JOHN NELSON, Air Reduction Sales Co., 3623 E Marginal Way, Seattle, Wash.

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SECRETARY—J. W. SHUGARS, Lincoln Electric Co., Moline, Ill.

ROCHESTER, N. Y. 1st Thurs.
CHAIRMAN—R. L. CATTANACH, American Laundry Mach. Co., 110 Buffalo Rd., Rochester, N. Y
ACTING SECY.—HAROLD J. KING, University of Rochester, Engineering Dept., Rochester, N. Y.

SAN FRANCISCO Last Fri.
CHAIRMAN—FRANK LONGO, Southern Pacific Co., San Francisco, Calif.
SECRETARY—R. E. LABAGH, Victor Equipment Co., 844 Folsom St., San Francisco, Calif.

ST. LOUIS 2nd Fri.
CHAIRMAN—A. S. SCHWARZ, John Nooter Boiler Works Co., St. Louis, Mo.
SECRETARY—H. C. CLOSE, Machinery & Welder Corp., 700 S. Spring Ave., St. Louis, Mo.

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CHAIRMAN—J. M. HUGHEN, Penn Shipyard, Inc., Beaumont, Tex.
SECRETARY-TREAS.—A. E. WISLER, Hughes Tool Company, 300 Hughes St., Houston, Texas.

TULSA, OKLA.
SECRETARY—JAMES B. DAVIS, Tulsa Testing Labs., Tulsa, Okla.

WASHINGTON, D. C. 2nd Tues.
CHAIRMAN—WM. E. MCKENZIE, 2909—5th St., S. E., Washington, D. C.
SECRETARY—B. J. BRUGGE, 410 Hill Building, 17th and I Sts., N. W., Washington, D. C.

WESTERN NEW YORK 3rd Fri.
CHAIRMAN—JOHN BOS, JR., 60 Westfield Rd., Eggertsville, N. Y.
SECRETARY—R. S. LANE, Ross Heater & Mfg. Co., 1407 West Ave., Buffalo, N. Y.

WICHITA, KAN.
SECRETARY-TREAS.—R. L. TOWNSEND, 829 S. Madison St., Wichita, Kan

YORK—CENTRAL PA.
CHAIRMAN—W. E. HOLLINGSHEAD, S. Morgan Smith, York, Pa.
SECRETARY—C. E. LEWIS KERCHNER, 290 W. Cottage Place, York, Pa.

YOUNGSTOWN, OHIO 2nd Mon.
CHAIRMAN & ACTING SECRETARY—T. D. FEATHERINGHAM, Youngstown Welding & Eng. Co., Youngstown, Ohio

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

CLEANING FOR WELDING

Essential production degreasing and maintenance cleaning required in aircraft and accessory manufacturing plants are thoroughly reviewed in the second edition of a newly revised, enlarged, 40-page manual just published by Oakite Products, Inc. Describing new developments in handling over 43 important, commonly recurring degreasing and cleaning operations, it is of particularly timely interest both to those executives responsible for the various types of work in which cleaning is an integral part and to the men charged with the actual performance of cleaning.

The manual gives practical data on the uses of tank immersion, washing machine, acidic, solvent, steam-detergent and pressure-spray methods for handling various degreasing and cleaning operations. Among those operations discussed are safely preparing aluminum alloy parts before such fabricating operations as welding, heat treating, Magna-flux testing, pickling, inspection and assembly; rust-proofing parts between operations; cleaning aluminum, magnesium and their alloys before anodizing or other protective chemical surface treatment; and degreasing work preparatory to electroplating, painting, black finishing, etc.

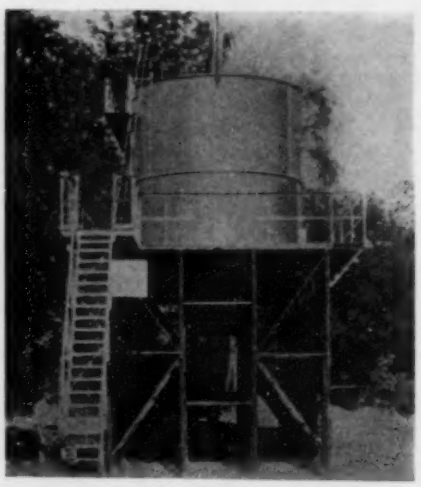
Of additional note is the description of production equipment maintenance cleaning as well as general housekeeping and sanitation work necessary in all aircraft and accessory manufacturing plants. A free copy of this helpful, informative manual will be sent upon request. Write to Oakite Products, Inc., 18E Thames St., New York, N. Y.

INDUSTRIAL SAFETY EQUIPMENT CATALOG

A new catalog published by the Safety Clothing and Equipment Co., Cleveland, Ohio, includes among its complete line of safety equipment many items in the welding field such as aprons, coats, jackets, pants, curtains, ear guards, gloves, leggings and spats and sleeves. Copy sent on request.

REFINERIES ON STILTS

Oil refineries in the Wabash Bottoms of Gallatin County, Ill., are mounting their pumps and tanks on welded pipe stilts 22 ft. above the ground so that operations will not be interrupted during the



Courtesy Hobart Bros. Co., Troy, Ohio

regular flood stages of the Ohio and Wabash rivers. Stilts are usually built by local job shop welders and constructed from old drill pipe.

NICKEL SOURCES SHOULD BE ADEQUATE FOR ESSENTIAL WAR NEEDS

Copper Cliff, Ont. Dec. 30—Increased capacity for the production of primary nickel coupled with salvage of nickel-bearing scrap and conservation efforts now provide sources of nickel which should be adequate for vital war needs, according to Robert C. Stanley, Chairman and President of The International Nickel Company of Canada, Limited, in a review of the nickel industry for the past year.

In connection with the Company's $35,000,000 expansion program, announced a year ago, Mr. Stanley said that it had progressed to a point where it makes possible an increase in productive capacity of 50,000,000 pounds annually over the 1940 rate of production. This was the increase in capacity rate promised when the expansion program was announced.

Despite this increased supply Mr. Stanley warned that efforts to recover alloy scrap must be intensified if the war needs of the United Nations are to be met promptly. He also commended measures taken by industry to conserve alloys.

"The importance of scrap metal salvage can not be overemphasized. The heaviest demand for nickel today is for use in alloy steels. Nickel in alloy steel scrap, if delivered to the mills in suitable form, can supplement primary nickel. Thus scrap can relieve much of the burden from our mines and refineries.

"While much more alloy scrap is being used today than was used a year ago, there are indications that a great quantity of nickel-bearing scrap is still available for steel furnaces. Efforts of the Company's personnel and facilities are being used in cooperation with the Canadian and United States Governments to return more of this available metal to war industries.

"Members of the Company's technical staff and field office personnel have been mobilized to aid nickel-consuming industries reduce nickel requirements where practicable, to advise on the most economical use of nickel, and to help the conservation of nickel by changing specifications. Such measures initiated by government and industry have played an important and constructive role in lessening the demand upon primary alloy production.

"A most important conservation measure in the United States was the development of the National Emergency steels. These steels represent a joint development by the U. S. War Production Board and the American Iron and Steel Institute. National Emergency steels, as their name indicates, have been brought into being to serve a definite purpose—the spreading of available alloys as widely as possible. The receipt of alloy scrap to date has been sufficient to supply almost the entire need of the National Emergency steels. Available information indicates that almost no primary nickel is required now for these steels."

ARC-WELDING CONTROL

A unique type of arc-welding control, which enables the welder to speed up his work and do a more accurate job, was announced by The Lincoln Electric Company of Cleveland.

ELECTROLOY ALLOYS for RESISTANCE WELDING ELECTRODES and DIES

Spot
Seam
Butt
Flash
Projection

ELECTROLOY ALLOYS were developed specifically for the resistance welding industry. ELECTROLOY ALLOYS cover the full range of physical properties necessary to the manufacturers and users of resistance welding equipment.

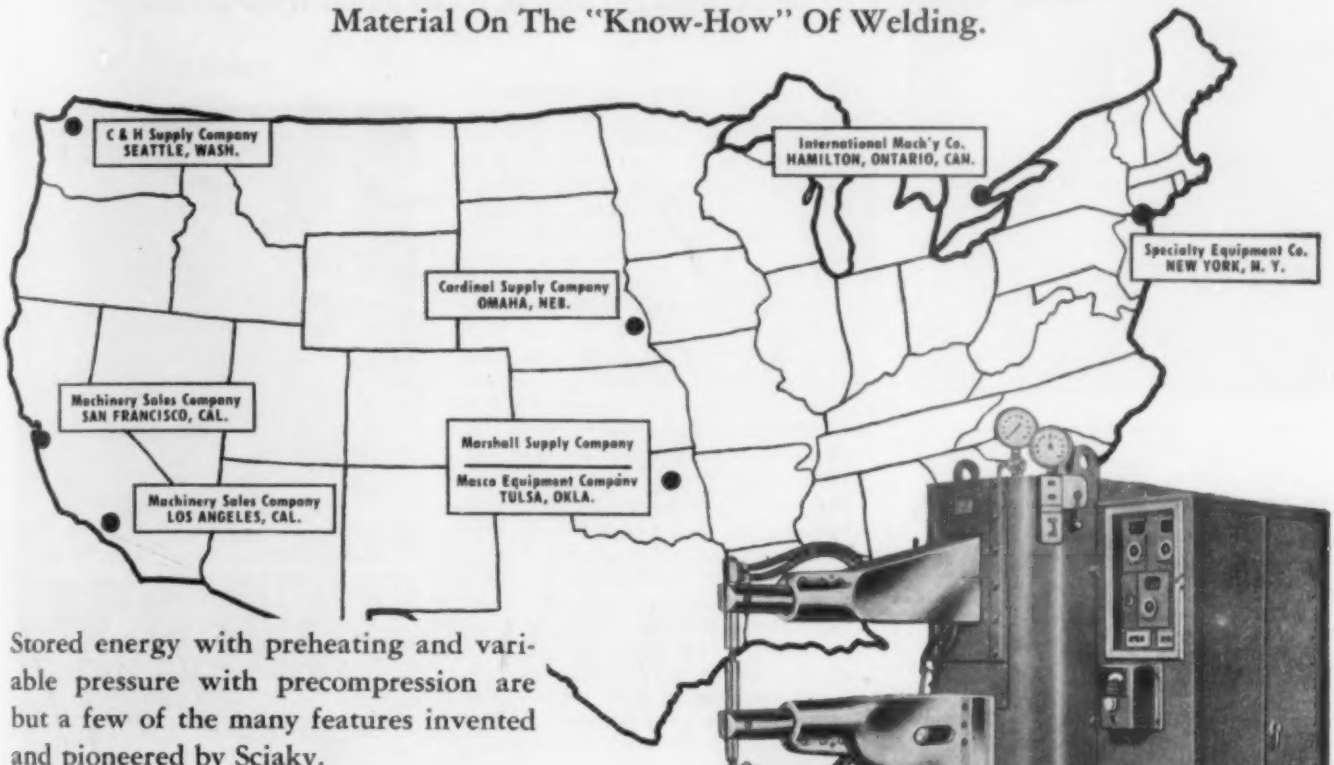
Our engineers will be glad to make recommendations for your special electrodes. Submit samples or specifications.

Catalog and prices available on request.

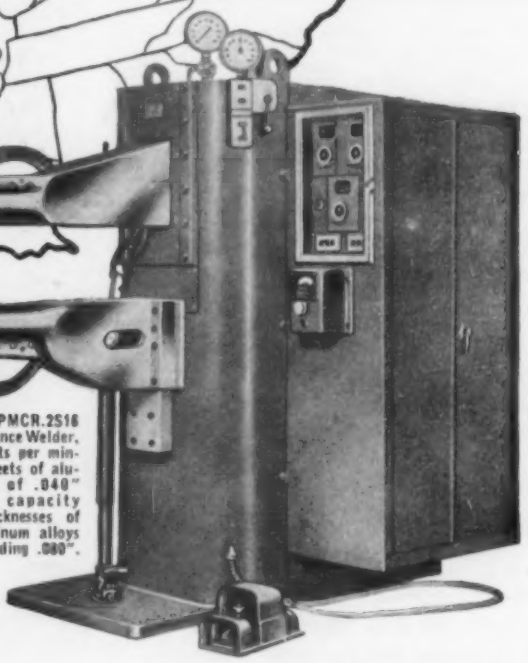
THE ELECTROLOY COMPANY, Inc. 1600 Seaview Avenue, BRIDGEPORT, Connecticut

FOR SERVICE
Call in Sciaky

When Welding Problems Confront You, Our Engineering and Metallurgical Staff Are Ready To Serve You. Here You Will Find A Wealth Of Informative Material On The "Know-How" Of Welding.



Stored energy with preheating and variable pressure with precompression are but a few of the many features invented and pioneered by Sciaky.



Sciaky Type PMCR.2S16 Electric Resistance Welder, welding 70 spots per minute, on two sheets of aluminum alloy of .040" each. Welding capacity from two thicknesses of .016" in aluminum alloys up to and including .080".

Sciaky provides these advantages:

- ... Low Current Cost
- ... No Special Power Lines
- ... Sound Uniform Forged Welds
- ... Complete Automatic Operation
- ... High Speed Production
- ... Minimum Maintenance
- ... No Special Training Required for Operators

"It's All in The Sciaky Process."

A complete line of Spot, Seam, Portable, and Stored Energy Welding Machines: DC and AC.

Write for Informative Literature

SCIAKY BROS.

Manufacturers of a Complete Line of D.C. and A.C. Electric Resistance Welding Machines

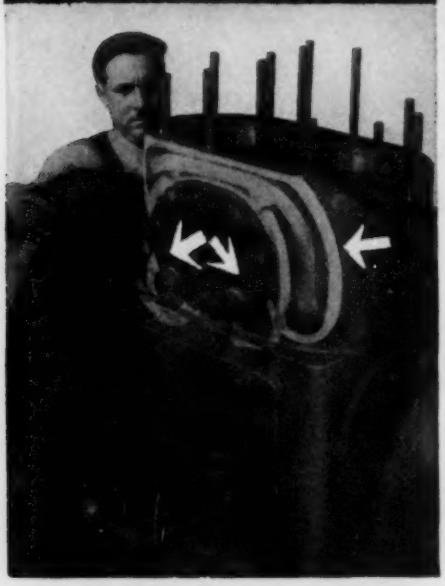
4915 W. 67TH ST., CHICAGO, ILL.

SCIAKY

PROCESS ELECTRIC RESISTANCE WELDING
STORED ENERGY · VARIABLE PRESSURE
WITH PREHEATING · WITH PRECOMPRESSION

Castolin Eutectic

LOW TEMPERATURE WELDING



Large two cylinder air compressor with badly cracked water jacket. Salvaged with Castolin Eutectic Low Temperature Welding Alloy. No general preheating. Time: 1½ hours.

IMPROVED RECLAMATION OF CAST-IRON CASTINGS

Why waste time and materials? Reclaim broken, cracked, worn or defective castings, easily, economically. Use Castolin Eutectic Alloy #14 (gas welding) and Castolin Eutectic Alloy #24B (AC–DC metallic arc). These new low temperature welding alloys assure you of a completely machinable, color matching, stress and distortion free weld every time.

Prominent manufacturers now use Castolin Eutectic Low Temperature Welding Alloys #14 & #24B in place of "hard to get" bronze welding rods. Castolin Eutectic Alloys #14 & #24B contain no scarce metals . . . available with priority A9.

Write for DATA BOOK E8

Castolin Eutectic Low Temperature Welding Alloys are the *original low temperature alloys* that are revolutionizing *production welding, maintenance welding* and *salvaging* in war plants throughout the nation. There are 38 specialized rods for every metal and every welding job. Made only by Eutectic Welding Alloys Company.

Tool Salvaging Poster for your Shop Free!

Some territories available for Manufacturers Representatives

EUTECTIC WELDING ALLOYS CO.

40 Worth St. New York, N. Y.

Lincoln Electric Company's arc welding "Lincontrol" shown here is unique in the ease with which it is operated and in its effectiveness. It is strapped on the foot and is almost as light as a shoe

This control, called the "Lincontrol," which is almost as light as a shoe, is strapped onto the welder's foot and enables him to move about with it freely It is specially intended for aircraft welding, but is applicable for welding of light-gage sheet metal of all kinds. Because it is so easily used, it will be a boon to women welders, who are taking up this type of work in aircraft plants in increasing numbers.

With the control strapped to his foot (see illustration), the welding operator merely presses down on the pedal which moves the pin to operate a current control. As he exerts pressure he increases the current.

This permits very accurate control over the welding arc, and achieves in one unit the same results as both the so-called "hot-start" and "crater eliminator." Because he has complete control, he can adjust the arc at any time without changing his position. Yet while welding in and around a fuselage assembly on "pick-up" work, he can move around at will without the hindrance of constantly keeping his foot in one place as is necessary with conventional foot controls.

Thus, the control eliminates the necessity of making adjustments on the welding machine, due to such things as minor changes in thickness, and changes in fit-up and enables the operator to weld in any position which he finds convenient or comfortable. The complete control of the arc gives an improvement in the quality of the weld, reducing the danger of a weld burning through or getting poor fusion or penetration.

Photo A

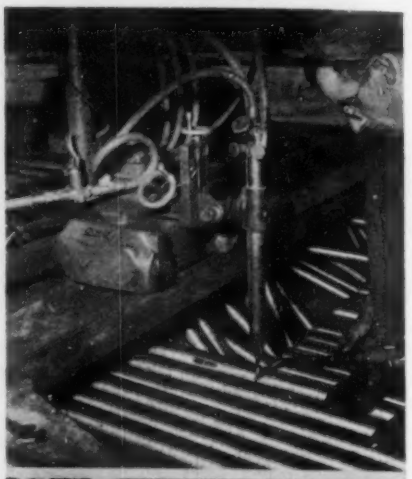


Photo B

FORGING BLANKS ARE FLAME-CUT

Round and square steel bars are cut into forging blanks by these oxyacetylene cutting machines. The blanks will be forged into shells.

The bars are laid down side by side on each cutting bed over which moves a bridge gantry with a track support for the cutting machine. Cutting is continuous from one side of the bed to the other over the entire row of bars. A manually operated blowpipe, as shown in Photos *A* and *B* preheats the starting edge of the adjacent billet, thus permitting a continuous and uniform cutting speed.

The square bars, each 6 in. long, will each make one shell. Round bars are cut into 24-in. lengths, each of which will be forged on an upsetting machine into twin shells.

ALL-WELDED STATUE HONORS CHURCHILL

Seeking out unusual applications of electric arc welding, not only utilitarian but also in objects of art, etc., has long been a

VICTOR

Underwater Cutting Torch

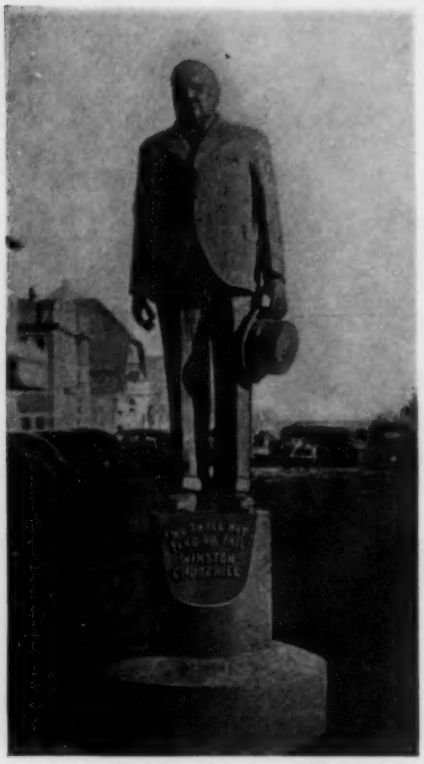
The VICTOR Underwater cutting torch is the result of years of practical experience and the suggestions made by many of our greatest divers.

The torch weight, its over-all size, freedom from protruding parts, heating efficiency at all encountered depths, and cutting speed, are the result of many years of field testing.

Divers cannot gamble with questionable equipment . . . emergencies demand the utmost dependability.

VICTOR EQUIPMENT COMPANY

FOLSOM STREET 3821 SANTA FE AVENU



hobby of field representatives for P&H welders and welding electrodes. An outstanding example recently discovered by Norman Peden of Canadian Fairbanks-Morse Co., exclusive Canadian distributors for P&H welding equipment, is this all-welded likeness of Britain's Prime Minister Winston Churchill. It stands 18-feet high at a main street intersection of Moose Jaw, in Canada's expansive, Saskatchewan wheatlands. The statue weighing over 2600 lb., was sculptured by welding students of Moose Jaw Technical High School in about two months of spare time, under the guidance of Instructor F. Clarke, with about 65 lb. of welding electrodes being used in its making. At the base appears the inscription: "We shall not flag or fail—Winston Churchill." A leading authority on welding, Mr. Clarke has not only trained most of the welding operators working in Saskatchewan industries, but acts as consultant on welding problems for various firms throughout the Province. (Photo by H. B. Jolson, Science Instructor, Moose Jaw Technical High School.)

ELECTRONIC SPOT WELDING CONTROL

A new electronic half-cycle, synchronous control for the precise operation of resistance-welding machines has been announced by the General Electric Company. Mounted in a protecting cabinet, the control is furnished in two types: the CR7503-A136, which also includes a welding transformer and is designed for bench mounting, and the CR7503-A133, which is without a transformer and is designed for wall mounting. Both types can be used either with tongs or with a suitable bench welder.

The control features a new tube, the easily replaced GL-415; a new circuit which makes higher-speed welding possible; and a simplified initiating circuit which improves performance and reduces maintenance. The new design also incorporates heat control by the phase-shift method. The heat adjustment is made by a dial mounted on the front of the cabinet.

The control facilitates the welding of tinned copper, steel, or alloy wires; of studs from 0.01 to 0.05 inch diameter to flat surfaces, with little or no indentation on the opposite surface of the metal; and the spot welding of unusually thin (less than 0.01 inch) pieces of stainless or mild steel, nickel, or silver to brass or bronze, with negligible oxidation or discoloration.

The control also makes possible the welding of low resistance joints which are unaffected by temperatures considerably in excess of 125 C, the point at which certain types of soldered joints weaken and often collapse. This results in the complete elimination of solder, with a corresponding saving of tin, and a saving of approximately 50 per cent in time. Also, in many cases it greatly simplifies the problem of training new employees, since the technique of resistance welding is learned much quicker and with less waste of material than in the case of soldering.

SECTION ACTIVITIES

BOSTON

Over 200 attended the joint meeting the Boston Section held with the Engineering Section of the Massachusetts Safety Council and the Boston Chapter, American Society of Safety Engineers, on Thursday, January 7th. The program consisted of the following:

1. "Welding Hazards—Their Protection and Avoidance."

(*a*) Acetylene Torch—eye protection, storage and handling of tanks, fire hazards, protective clothing.

(*b*) Arc Welding—electrical connections, eye protection, protective clothing.

(*c*) Removal of fumes—blowers, ducts and ventilation.

Speaker and supervisor of demonstrations was E. H. Swimm of the B. F. Sturtevent Co. Protective clothing demonstrated through courtesy of American Optical Company and A. L. Postman of Waltham.

2. "Pressure Vessel Explosions—with special consideration to hot water tanks." This was presented by Smith & Dale, New England representatives of the Watts Regulator Co, who used slides and motion picture with their talk.

CHICAGO

The December meeting was held on Friday the 18th. Mr. John A. Rea, of The Linde Air Products Company, Indianapolis, presented a paper entitled, "Improved Methods of Flame Cutting." Mr. Rea outlined the development of flame cutting by machine methods and brought from the early day up to the present time.

The meeting was preceded by a dinner and a pre-meeting movie. An interesting sidelight was a demonstration of the manufacture of synthetic rubber by representatives of the B. F. Goodrich Company.

CLEVELAND

The regular meeting of the Cleveland Section of the AMERICAN WELDING SOCIETY was held Wednesday evening, January 18th, at 8 o'clock at the Cleveland Engineering Society.

The main feature of the evening was a paper entitled, "Planning for Production Cutting, Welding and Heating in West Coast Ship Yards" by J. G. Magrath, engineer, Applied Engineering Department, Air Reduction Sales Co., New York, N. Y.

Today, the human symbol of modern shipbuilding is the welder. Without the welding arc and the cutting torch, the speed with which we are building the victory fleet would not be possible. The subject of this paper clearly showed why and how the arc and the cutting oxygen stream have revolutionized the shipbuilding industry. Mr. Magrath discussed the planning of the yard and its arteries, the supply line systems of oxygen and acetylene distribution. He pointed out the care exercised in the maintenance of apparatus and training of welders and cutters. He outlined the complete procedure through the plate yard, the plate and assembly shops, the pipe and machine shop and then through the yards on the skids and to the ways and final outfitting. A complete picture of how these processes serve from the laying of the keel to the trial cruise was provided in this paper.

The Coffee Talk, "Canine Cadets" by M. W. Darling, gave some inside facts on the "Seeing Eye" dogs.

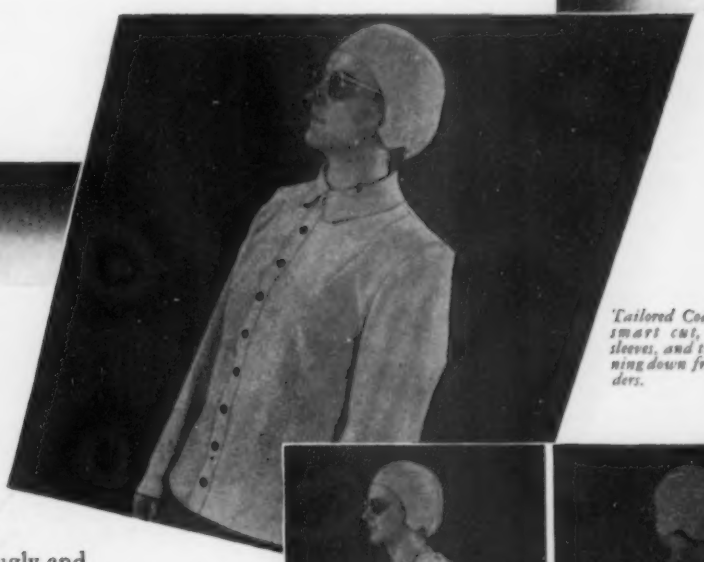
COLUMBUS

Color movies, "Unfinished Rainbows" and "How to Weld Aluminum," were

NEW

AO

Protective Clothing Especially Tailored for Women Welders



Tailored Coat—Note smart cut, shaped sleeves, and tucks running down from shoulders.

Tailored Sleeves and Tailored Apron — Note how Tailored Cap protects hair.

Tailored Overalls—Note how flared trouser legs protect feet.

Women can now obtain welders' leathers that not only offer adequate protection but also fit snugly and comfortably, look smart, and withstand severe use and abuse. Every garment in the new AO line of Tailored Protective Clothing has been styled according to dressmaker patterns. As a result, these leathers permit free and easy movement of the body, enabling women welders to turn out more and better work — with less fatigue. Expert design also adds notably to garment life — especially in the sleeves, at the waistline, and across the shoulders.

AO Tailored Protective Clothing is made of specially selected chrome tanned cowhide. It is as light in weight as possible, consistent with adequate protection. All garments have a soft suede-like appearance. Included in the line are Tailored Coats, Short Jackets, Overalls, Sleeves, Aprons, and a Cap to protect women's hair and ears during the welding operation. For further details, get in touch with your nearest AO Branch Office.

American Optical

COMPANY

SOUTHBRIDGE, MASSACHUSETTS

shown through the courtesy of the Aluminum Company of America at the January 8th meeting held at Battelle Memorial Institute.

DETROIT

The Detroit Section has had three meetings in the past week, two at Flint on Thursday, January 7th, and the evening meeting at Detroit, Friday, January 8th. Mr. H. O. Westendarp, Jr., Welding Engineer, General Electric Co., Schenectady, N. Y., was the speaker at all of the meetings and covered the subject, "The Proper Use and Manufacturing of Arc Welding Electrodes."

He described the need for coatings and the types of coatings for the different uses of electrodes. He further developed the right and wrong way of utilizing arc-welding rods. The talk was supplemented by slides and motion pictures. The Flint meetings were held at the Capitol Hotel and the Detroit meeting at the Detroit-Leland Hotel.

In the discussion at the Detroit meeting it was developed that an outstanding method of conserving stainless steel arc-welding rod had been developed by one of our members. It consists in the resistance welding of a mild steel rod about 4 in. in length to the holder end of the conventional stainless steel coated rod. The result means that a 15% increase in rod deposit was effected and, unexpectedly a tremendous increase in electrode holder life resulted. The heat developed at the holder was substantially decreased and increased comfort to the operator was marked.

Those present were able to learn at first hand of an accomplishment which is of tremendous importance. The next regular scheduled meeting of the Flint Section is February 16th, in conjunction with the American Society for Metals. Dr. Hensel of P. R. Mallory & Co. will address the combined societies on "Welding in the War Program." The Detroit Section meeting is scheduled to be held in the Horace H. Rackham Building.

INDIANA

A "Demonstration and Discussion of Arc Blow" was given by Mr. A. B. White, Welding Engineer at the Westinghouse Laboratories, at the December 18th meeting of this Section held at the Senior High School, New Castle, Ind. Mr. White disclosed that welding studies at the Westinghouse Labs. have uncovered new ways to outwit "arc blow," worst enemy of the electric welder.

KANSAS CITY

The Third Regular Meeting of the Kansas City Section of the AMERICAN WELDING SOCIETY was held Tuesday evening, December 1st, in the Pine Room at Fred Harvey's. Chairman Wm. S. Farr presided.

After the sumptuous dinner, Mr. Ed. Cellwork, in charge of membership, reported seven new members. Due to inclement weather, the inception of gasoline rationing and the war effort, the attendance was somewhat less than usual.

The Kansas City section was fortunate in its choice of speaker and subject. At the November meeting, Mr. Francis Hohenschild had presented the first three of the G. E. films, "The Inside of Arc Welding." "How to weld" and "How NOT to weld" were both clearly demonstrated. At the December meeting an interesting contrast was presented. Illustrating his address with slides, Mr. Morris Foot, plant superintendent of the R. G. Le Tourneau Co., of Peoria, Ill., explained that his firm used rotating jigs to bring the work to the position most convenient for the welder. This resulted in superior and more rapid production without the necessity of using welding "artists."

A fine attendance, January 5th, greeted Chairman Wm. S. Farr at the dinner hour. Unanimously and enthusiastically, the assembled group voted to purchase a $100 war bond in the name of the Kansas City Section of the AMERICAN WELDING SOCIETY.

After an excellent dinner, Mr. Farr announced that Mr. J. A. Hall, engineer with the Kansas City Structural Steel Company, had been suddenly called away from the city on company business, and would therefore be unable to present his address as scheduled. Mr. Farr then directed attention to the saving of welding gas and repair and maintenance of gages, hose and distribution lines. Mr. Ed. Anderson also stressed the necessity of using electrodes completely in order to conserve this valuable material. Mr. Francis Hohenschild, Welders' Supply and Repair Company, then presented the remaining three G. E. films on "The Inside of Arc Welding," much to the enjoyment of all. Before adjournment, Mr. Farr announced that there would be no February meeting, but all were asked to take an active part in the Speed-up Clinic to be held in Kansas City for the entire Midwest, January 29th, in the afternoon and evening. This information was enthusiastically received, and the Kansas City Section will be there in force.

MILWAUKEE

"Maintaining Ourselves in Education" was the title of an after-dinner talk by J. J. Simon of the West Allis School Board, which talk preceded the welding address at the December 23rd meeting held at Cudworth Post, American Legion. The welding address was given by E. R. Seabloom, supervising engineer, Crane Company, who spoke on "Welding Design and Materials for Piping, Valves and Fittings." The talk covered test methods employed in the selection of materials for component parts that enter into the design of fluid conveying equipment.

NEW YORK

The New York Section of the AMERICAN WELDING SOCIETY cooperated with the War Production Board in staging a War Production Conference on January 7, 1943, at the Hotel Pennsylvania in New York. The purpose of this conference was "to exchange information and experience on engineering, management, shop and manpower aspects of war production problems." The meeting began with a dinner which was attended by more than one thousand guests of the conference. Following dinner the meeting broke up into a series of individual discussion panels on subjects such as manpower problems, machine shop problems, chemical plant equipment, metallurgical problems, and welding problems.

The panel on welding problems was extremely interesting. The more than one hundred fifty people present had an opportunity to have questions answered on all types of applications of welding, cutting and allied processes used in the fabrication and repair of tools, equipment and other metal products. Credit for the success of this meeting is due to the following members of the New York Section who participated: *Chairman*, H. R. Morrison, The Linde Air Products Company, New York, N. Y.; *Secretary*, George Schneider, Acetylene & Welding Equipment Co., Brooklyn, N. Y. Discussion leaders and the subjects covered were as follows: "Electric Arc Welding," E. Vom Steeg, Jr., General Electric Company, New York, N. Y.; "Oxy-Acetylene Welding, Cutting and Treating Processes," A. N. Kugler, Air Reduction Sales Company, New York, N. Y.; "Silver-Alloy Brazing," A. M. Setapen, Handy and Harmon, New York, N. Y.; "Resistance Welding," R. S. Donald, Thomson-Gibb Electric Welding Company, New York, N. Y.

The regular monthly technical meeting of the New York Section was held on Tuesday, January 12, 1943, at the Engineering Society's Building. Technical Chairman for the evening was J. G. McIlhiney, flame-hardening specialist, Air Reduction Sales Co., New York, N. Y.

The speaker for the evening was Mr. Arthur K. Seemann, engineer, The Linde Air Products Company, New York, N. Y., who spoke on the subject "Flame Hardening and Flame Softening." Mr. Seemann presented a motion picture and lantern slides with a running commentary on the important subjects of flame hardening and flame softening. In his talk he included a detailed description of numerous practical applications. Among the interesting items featured here the flame hardening of tank sprockets, gears and steel mill rolls.

The evening opened with a half-hour question and answer period conducted by R. E. Bedworth, Westinghouse Electric and Mfg. Company, New York, N. Y.

NORTHERN NEW JERSEY

The December 15th meeting included the annual welding forum which was exceptionally well attended and interest ran at a maximum. The questions had been submitted by all members and were answered at random from the audience, which tended toward informality that was highly acceptable to all. In addition, reels 4 to 6 on "The Inside of Arc Welding" were shown.

The following is the schedule of meetings for the next few months.

"UNITED" skills operating within this organization are devoted exclusively to the designing and manufacturing of electronic power tubes. This intensive degree of specialization is reflected in tubes achieving an amazing record of performance through the gruelling punishments of war.

"UNITED" skills, cooperating hand in hand in this plant, include eminent engineers recognized by the industry as pioneers in development of electronics. On the grounds of priceless, time-tested experience alone, the products of these pioneers inspire confidence.

"UNITED" skills in electronics may be identified by the name "United" on each tube. Look for it when peace permits the enlarged use of electronic power tubes for radio, industrial and an ever-growing number of applications.

UNITED ELECTRONICS COMPANY • NEWARK, N. J.

UNITED *Skills in* ELECTRONICS

February 16th—Film. Title to be announced. Remarks. Honorary Chairman, C. W. Bryan, Jr., vice president, Federal Shipbuilding & Dry Dock Co. "Welding in Shipbuilding," by J. L. Wilson, American Bureau of Shipping.

March 16th—Film, "Fabrication of Large Diameter Pressure Vessels." Courtesy M. W. Kellogg Co. "Welded Pressure Vessels." Speaker to be announced.

April 20th—Film, "The Making and Shaping of Steel." Courtesy U. S. Steel Corp. "Elementary Metallurgy as Applied to Welding of Steels," by Dr. R. H. Aborn, U. S. Steel Corp.

May 18th—Annual Meeting

ROCHESTER

The January meeting of the Rochester Section of the AMERICAN WELDING SOCIETY was held Thursday, January 7th, at Todd Union, University of Rochester, River Campus, with Robert Cattanach, president, presiding.

The educational feature of the meeting was presented by Mr. Hunt of the Hartford Steam Boiler Inspection and Insurance Co. His talk on "Procedure Qualifications," followed by a group discussion, was enjoyed by all.

"A Thrill a Minute," a Castle film presented by Ray Englert, furnished the entertainment. During the meeting a black-out occurred at which time Ray Hand of Gleason Works and this Section's past secretary, Paul James, of Lincoln Electric Co., took over and told stories of their personal experiences.

ST. LOUIS

The following is the program of meetings for the balance of the season.

Feb. 12th—"Aluminum Welding" by a representative of the Engineering Department of Aluminum Company of America.

Mar. 12th—"Jigs and Fixtures" by Mr. R. W. Sternke of the Lakeside Bridge & Steel Company, Milwaukee, Wisc.

Apr. 8th—"Information Please." It is expected that this meeting will be one of the most outstanding of the year, and it is to be held as a joint meeting with the Engineers' Club of St. Louis. Members and friends are urged to attend with prepared questions for open discussion. All questions are to be answered by a Board of Experts, and the entire meeting is to be led by Mr. F. C. Fantz of the Midwest Piping & Supply Company of St. Louis.

May 14th—"Welding Design and Materials for Piping Valves and Fittings" by Mr. Eric Seabloom of Crane Company, Chicago.

June 11th—This is the last meeting in the fiscal year, and consists of a brief business session, followed by a dinner and entertainment.

It is also interesting to know that this Section is very actively engaged in the promotion of welding and recognition of same for the St. Louis Building Code. It is expected that some very fine results will be shown this year.

SOUTH TEXAS

The new Secretary-Treasurer for this Section is Mr. A. E. Wisler, Hughes Tool Company, 300 Hughes Street, Houston, Tex.

Meeting on December 10th was held at the Ben Milam Hotel, Houston. Mr. A. F. McColl of North American Aviation was scheduled to speak but was unable to be present. Mr. Newman of Wessendorff, Nelms and Co. presented a very interesting film, entitled "Welding of Aluminum" by the Aluminum Company. Mr. R. F. Arnoldy of The Linde Air Products Co. gave an interesting résumé of flame-cleaning applications to war production of shells, bombs and ship plate.

YORK-CENTRAL PENNSYLVANIA

The December meeting of the York-Central Pennsylvania Section was held December 16th at the Engineering Society of York Building. Mr. Fred. L. Plummer, chief research engineer of Hammond Iron Works, Warren, Pa., delivered a talk on "Welded Bridges, Buildings and Tanks."

The part of the lecture on bridges was very interesting. Besides giving designs and practices of European countries, it covered failures and probable cause of failure of European structures up to the outbreak of present hostilities. Design features of several American structures were also discussed in comparison.

The welding process is showing an increased use in the construction of buildings

Some cities have adopted codes which will permit the use of welding and it is very likely that new impetus will be given when the present world conflict is successfully concluded.

The slides on tanks showed many novel designs and the flexibility in the use of the welding process.

List of New Members

December 1 to December 31, 1942

BIRMINGHAM

Tinsley, C. R. (C), U. S. Pipe & Fdy. Co., Birmingham, Ala.

BOSTON

Allen, Earle F. (B), Manning, Maxwell & Moore, 5 Watson St., Boston, Mass.
Atkinson, Henry M. (C), 4 Atkinson Circle, Winthrop, Mass.
Forand, James L. (C), 12 Sachem Ave., Worcester, Mass.

CANADA

Fleming, Russell (F), P. O. Box 35, Port Dalhousie, Ont., Canada.
Smith, Oscar (C), 1426 Haywood Ave., Hollyburn, B. C., Canada.

CHATTANOOGA

Smith, Walter E. (C), Combustion Engrg. Co., 1032 W. Main St., Chattanooga, Tenn.
Sparks, James J. (C), 1611 Hawthorne St., Chattanooga, Tenn.
Stansberry, Joe A. (C), Combustion Engrg. Co., 1032 W. Main St., Chattanooga, Tenn.

CHICAGO

Biesk, Robert J. (D), 9710 Melvina Ave., Oak Lawn, Ill.
Czelusniak, Fred (C), 3625 S. 55th Court, Cicero, Ill.
Erwin, James B. (C), Wallace Supplies Mfg. Co., 1310 Diversey Parkway, Chicago, Ill.
Schuman, Cecil W. (D), 4858 Cottage Grove Ave., Chicago, Ill.
Sennebogen, John A. (D), 112 N. Wilmette Ave., Westmont, Ill.
Skuranskis, Anthony J. (C), 3939 S. Rockwell, Chicago, Ill.
Wilson, Ward A. (C), Cyclone Fence Div. of A.S.W. Co., North Chicago, Ill.

CLEVELAND

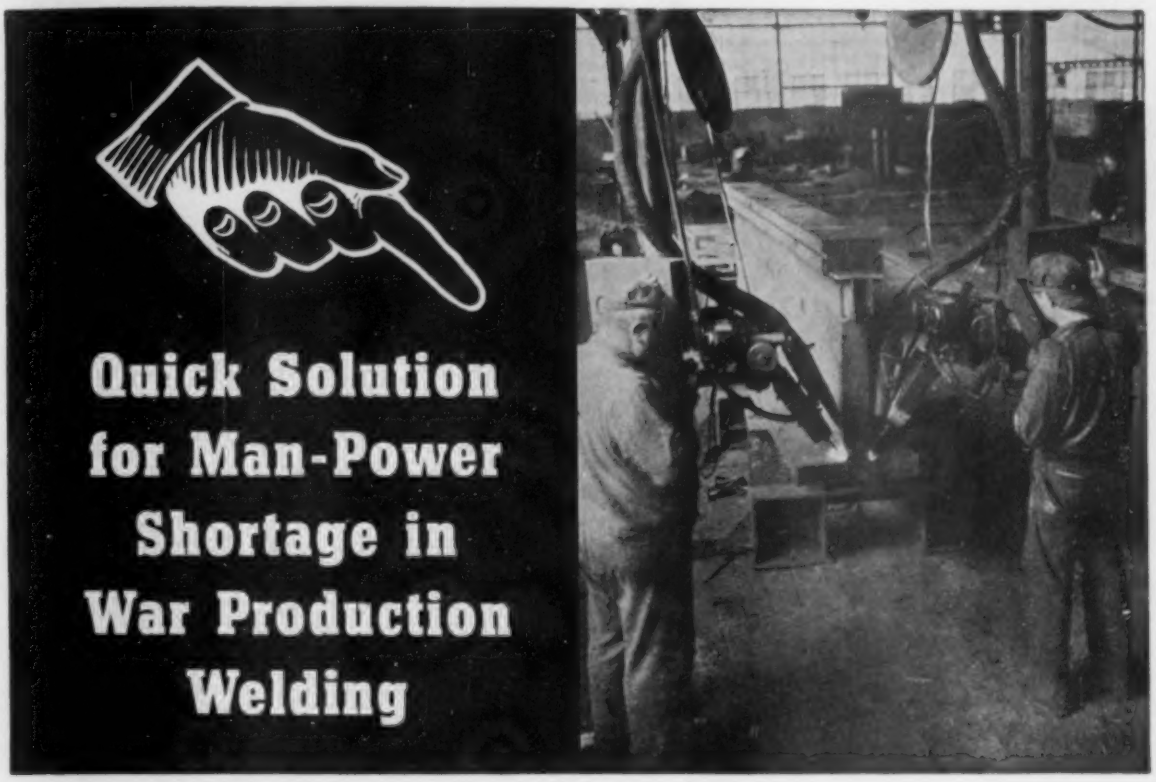
Magee, Bronson R. (B), C. M. Barber-B. R. Magee Struc. Engr., 237 Hanna Bldg., Cleveland, Ohio.

COLUMBUS

Evans, Sidley O. (C), Ohio State University, Dept. of Elec. Engrg., Columbus, Ohio.
Romas, Marion V. (D), 39 S. Hartford Ave., Columbus, Ohio.
Ryan, Robert S. (F), 347 W. 7th Ave., Columbus, Ohio.
Sweet, Foster (D), 64 Eldon Ave., Columbus, Ohio.
Trumbull, Red (C), 1788 Rainbow Park, Columbus, Ohio.
Vickers, S. E. (B), 686 Chelsea Ave., Columbus, Ohio.

DETROIT

Beatty, George M. (B), 2212 Mackin Rd., Grand Blanc, Mich.



Quick Solution for Man-Power Shortage in War Production Welding

HERE is a way to turn one experienced arc welding operator into two, three or even four, practically overnight. Within the next three months application of the Unamatic Welding process to war production that logically calls for it, could be equivalent to finding several hundred expert welders.

War production calling for large quantities of similar welds of precision quality should be done wherever possible by the Unamatic process. This would increase the usefulness of experienced welders, of whom there are far too few right now, and relieve the desperate shortage of manual operators for other work just as vital which cannot be brought under the Unamatic process.

Besides providing high-speed non-stop production on war work Unamatic welding is less fatiguing, requires far less concentrated attention and eliminates variability in the work. In some types of light work women operators are as capable as men.

Under today's conditions the possibility that you can use the Unamatic process to increase war production and at least partially solve the man-power problem, should be A-A-1 in Priority for your attention. We shall gladly send literature or answer specific questions through sales office nearest you. Write today.

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Don Carlos, Richard (C), 12528 Second, Highland Park, Mich.
Galbraitt, Neil J. (B), 1119 Reid Rd., Grand Blanc, Mich.
Lester, Frank J. (C), 730 N. Dragoon St., Detroit, Mich.
McDaniel, Paul (B), 343 Ferndale Ave., Flint, Mich.
Olson, Raymond E. (B), 2409 Francis Ave., Flint, Mich.
Parker, Ralph K. (B), 805 E. Ruth Ave., Flint, Mich.
Shutt, Lester (B), 11306 West St., Grand Blanc, Mich.
Skidmore, L. M. (B), General Motors Inst., Flint, Mich.

GEORGIA

Stellman, Michael C. (B), 1164 N. Highland Ave., N. E., Atlanta, Ga.

HAWAII

Elmhorst, Ernest (C), Hawaiian Gas Prods., Ltd., P. O. Box 2454, Honolulu, T. H.
La Porte, Le Roy (C), Hawaiian Gas Prods., Ltd., P. O. Box 2454, Honolulu, T. H.
Morgan, Wm. Alan (C), Hawaiian Gas Prods., Ltd., P. O. Box 2454, Honolulu, T. H.
Smith, George J. (C), Hawaiian Gas Products, Ltd., P. O. Box 2454, Honolulu, T. H.

INDIANA

Partain, Kenneth (D), 2218 S. 19 th St., New Castle, Ind.
Thompson, Albert A. (D), R. R. 1, New Castle, Ind.

LOS ANGELES

Alexander, C. S. (C), 4213 Ocana, Long Beach, Calif.
Frank, Jack P. (C), 2015 N. Fairview St., Burbank, Calif.
Gross, Bernard (B), Rohr Aircraft Corp., Ft. of H St., Chula Vista, Calif.
Long, Hershell O. (C), 927 W. 3rd St., Long Beach, Calif.
Luttrell, S. (C), 3765 Falcon Ave., Long Beach, Calif.
Pickerill, Grey H. (C), Fleet Welding School, Receiving Station, San Diego, Calif.
Richardson, J. E. (C), 8320—4th Ave., Inglewood, Calif.
Sommarstrom, Clifford E. (C), Waldrip Engrg. Co., 11810 Center St., Hollydale, Calif.
Waldrip, Wm. S. (C), Waldrip Engrg. Co., 11810 Center St., Hollydale, Calif.

MARYLAND

Eggen, Arvid (D), 1761 Montpelier St., Baltimore, Md.

MILWAUKEE

Bradshaw, Otto R. (B), 2026 S. 69th St., West Allis, Wis.

NEW YORK

Benson, Samuel (D), 400 E. 80th St., New York, N. Y.
Flechner, Melvin (D), 1726—52nd St., Brooklyn, N. Y.
Inman, Wm. D. Jr. (D), 796 E. 35th St., Brooklyn, N. Y.
Kammerman, Seymour (D), 6073 Gates Ave., Brooklyn, N. Y.
McCullough, Frank (D), 286 St. Johns Place, Brooklyn, N. Y.
Singer, Morris (D), 1021 Avenue St. John, Bronx, N. Y.
Smith, Sidney (D), 648 Linwood St., Brooklyn, N. Y.

NORTHERN NEW JERSEY

Boyar, Sidney (C), Frederick Gumm Chem. Co., 538 Forest St., Kearny, N. J.
Doucette, Roland J. (C), Frederick Gumm Chem. Co., 538 Forest St Kearny, N. J.
Gumm, John R. (C), Frederick Gumm Chem. Co., 538 Forest St., Kearny, N. J.
Raleigh, Charles, Jr. (D), 163 Elm St., Kearny, N. J.
Sizelove, Robert R. (B), 538 Forest St., Kearny, N. J.
Tilton, Andrew I, Jr. (C), 549 Linden Ave., Woodbridge, N. J.
Von Rohr, H. H. (C), 21 Hoburg Place, Montclair, N. J.

NORTHERN NEW YORK

Woodward, Stanley J. (D), 102 Jay St., Schenectady, N. Y.

NORTHWEST

Kvasnicka, W. J. (C), 2349 James Ave., N., Minneapolis, Minn.
Sandquist, Walter (B), 349 N. Hamline Ave., St. Paul, Minn.

OKLAHOMA CITY

Norman, J. W. (D), 1013 E. 6th St., Okmulgee, Okla.

PHILADELPHIA

Alexander, George W. (C), Dravo Corp., Wilmington, Del.
Bradway, Ralph D. (C), 821 Park Ave., Collingswood, N. J.
Linsky, Horace (C), Welded Steel Shapes, Inc., Coatesville, Pa.
Gorgas, F. Y. (D), 4030 Hartel Ave., Philadelphia, Pa.
Horton, C. R., Jr. (C), Dravo Corp., Wilmington, Del.
Mattson, John, Jr. (C), 6509 Paschall Ave., Philadelphia, Pa.
Ranshaw, C. E. (C), Dravo Corp., Wilmington, Del.
Seither, Albert B., Jr. (C), Taylor Forge & Pipe Wks., 938 Broad St. Station Bldg., Philadelphia, Pa.
Steely, I. C. (C), 809 Fairfax Rd., Drexel Hill, Pa.
Strawbridge J. Fred (C), 236 W. Walnut Lane, Apt. B-410, Philadelphia, Pa.
Walsh, George T. (B), Bok Vocational School, 8th & Mifflin, Philadelphia, Pa.

PITTSBURGH

Booth, D. A. (C), 214 Pine Rd., Edgeworth, Pa.
Dawson, A. J. (C), Dravo Corp., Neville Island, Pittsburgh, Pa.
Kline, R. Henry (D), R. D. 1, Mt. Pleasant Mills, Pa.

QUAD CITIES

Hadad, Michael H. (D), 428 Western Ave., Davenport, Iowa.

ROCHESTER

Berliner, William (F), 126 Westbourne Lane, Ithaca, N. Y.
Bridges, Wm. R. (B), 114 E. Hickory St., East Rochester, N. Y.
Dinino, John (D), 244 Spruce Ave., Rochester, N. Y.
Hylkema, Martin (D), 76 Presque St., Rochester, N. Y.
Liebschutz, Joseph (D), Rochester Scrap Baling Co., 20 Flint St., Rochester, N. Y.

ST. LOUIS

Grant, E. R. (B), Sverdrup & Parcel, 1848 Railway Exchange Bldg., St. Louis, Mo.

SAN FRANCISCO

Gommel, Ernest W., Jr. (C), The Stee Tank & Pipe Co., 1100—4th St., Berkeley, Calif.
Leyden, F. J. (B), 3511 Esmond, Richmond, Calif.
Roster, Harry E. (D), 315 Channing, Palo Alto, Calif.
Vorhauer, Raymond R. (C), 3884—24th St., San Francisco Calif.

WASHINGTON, D. C.

Di Giglio, Vito A. (C), 1426—21st., N. W., Washington, D. C.
McPherson, Bernice M. (C), General Delivery, Rockville, Md.

WICHITA

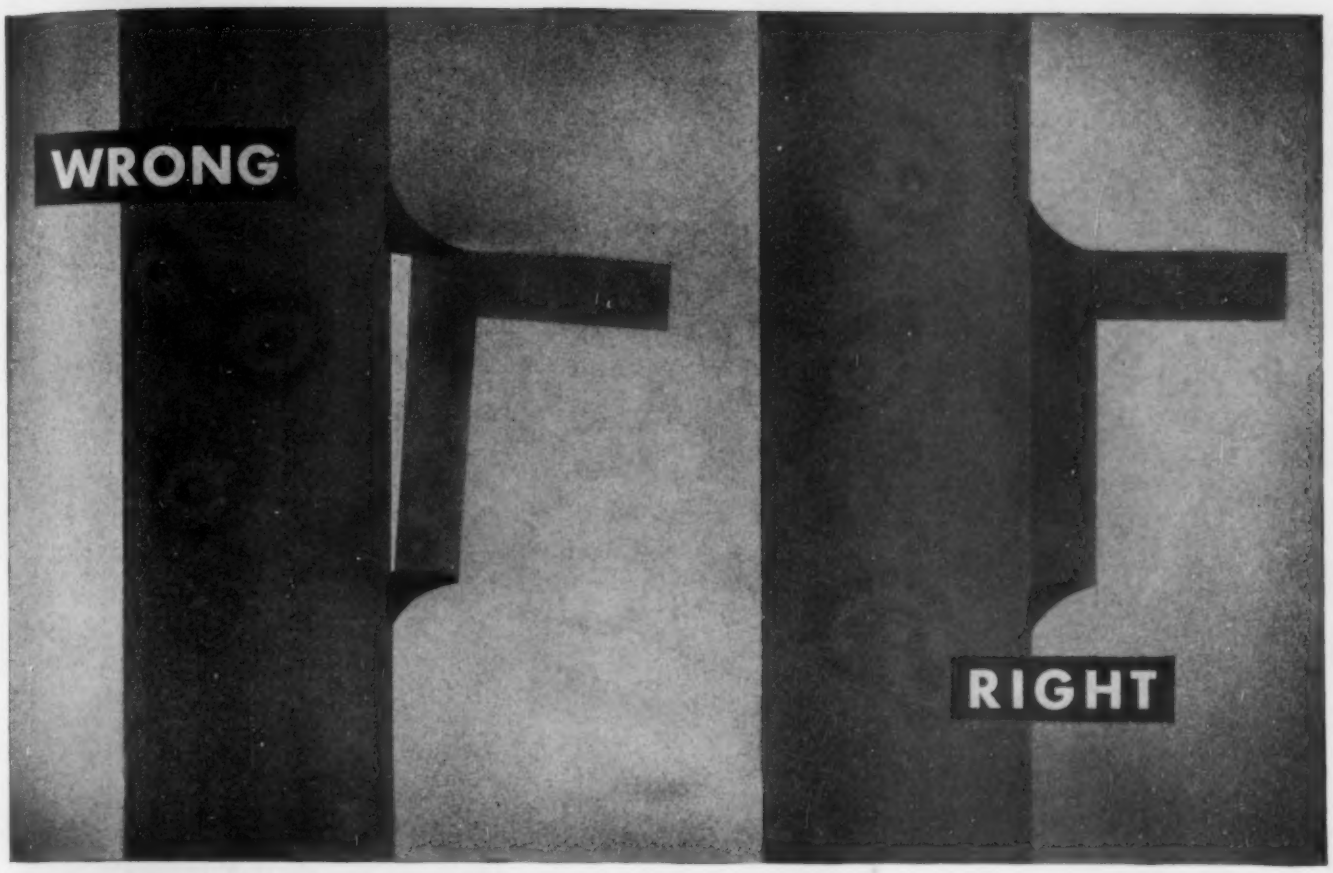
Barrett, M. A. (B), 610 N. Bluff St., Wichita, Kan.

YOUNGSTOWN

Waldo, Arthur W. (C), 4000 Hillman St., Youngstown, Ohio.

NOT IN SECTIONS

Andrews, Wm. (C), Estoril, 11 Lowther Drive, Enfield, Middlesex, England.
Batiuchok, Henry (D), P. O. Box 1463, Wilmington, N. C.
Bull, Frederick S. (C), Hobletts Cottage, Hemel Hempstead, Herts, England.
Butler, Robert (C), % Lincoln Elec. Co., Welwyn Garden City, Herts, England.
Castleman, K. Earl (D), Waddington, N. Y.
Dillard, Charles G. (C), Welders Supply & Equip Co., 1548 E. Cary St., Richmond, Va.
Doherty, Kevin (C), 12 Lidgett Park Grove, Leeds 8, England.
Forey, Edward T. (C), 183A Maida Vale, London W. 9, England.
Fox, Clifton P. (C), U. S. Naval Base, % G. A. Fuller Co., Argentia, New Foundland.
Gardner, H. St. G. (C), 5 Godfrey St., London S. W. 3, England.
Gitzen, Alfred J. (D), 2402 Barks Ave., Superior, Wis.
Greenaway, William G. (C), 8A The Hawthorns, E. Boldon, Co. Durham, England.
Hanner, Melvin (B), 311 S. Westland, Tampa, Fla.
Hignett, Harold W. G. (B), 52 Redway Drive, Whitton, Twickenham, England.
Hipperson, Alfred J. (C), 1, Rhodes Ave., Alexandra Park, London N. 22, England.



Showing waste of weld metal due to inaccurate fit-up. Errors of this kind can result in electrode consumption double or more of what is required.

HOW IMPROPER FIT-UP WASTES ELECTRODES

OPERATIONS prior to welding often affect the ultimate amount of weld metal required. Attempts of the welder to correct improper fit-up, for example, will result in waste of electrodes, as well as labor and power. ¶ To help conserve the vital supply of welding electrodes: (1) Every joint must be designed so that the minimum of weld metal can be used, without sacrificing strength. Irregular contours should be avoided wherever possible, and proper allowance for distortion caused by welding should be made. (2) Lay-out work, cutting and shaping must be done accurately, and close tolerances maintained. (3) Fitting-up must be accurate, jigs and fixtures being used wherever possible.

This is one of a series of advertisements on the important subject of electrode conservation. If you wish reprints of the series as they are issued, send us your name and address.

METAL & THERMIT CORPORATION

Specialists in welding for nearly 40 years. Manufacturers of Murex Electrodes for arc welding and of Thermit for repair and fabrication of heavy parts.

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Kullberg, Paul (B), Industrial Specialties Co., 940 S. E. 7th Ave., Portland, Ore.
Rincones, Luis Mendez (B), Taller Menco, Avenida Las Manquit, Las Delicias Sabana Grande, Caracas, Venezuela, South America.
Wooten A. B. (C), % Globe Aircraft Corp., Ft. Worth, Tex.

Members Reclassified

During Month of December

BOSTON

Miller, Robert Scott (from C to B), 4 Webber St., Malden, Mass.

CANADA

Moore, Allan M. (from D to B), 35 Kernahan Ave., St. Catherines, Ont., Canada.

CANAL ZONE

Wiff, Roon W. (from D to C), Box 1020, Balboa, Canal Zone.

CHATTANOOGA

Farmer, C. W. (from D to C), Center, Ala.

CLEVELAND

Bartenfeld, Wilford G. (from D to C), Channel Steel Hull Corp., Rockefeller Bldg., Cleveland, Ohio.
Dossett, William (from D to C), 1855 Colonade, E. Cleveland, Ohio.

INDIANA

Duchemin, Gus (from D to C), Sheridan, Ind.
Leffiler, Isaiah R. (from D to C), 2116 N. E. St., Richmond, Ind.

KANSAS CITY

Carrender, Walter (from D to C), 614 Packard St., Kansas City, Kan.
Richards, F. D. (from D to C), Garnett, Kan.

LAKE SHORE

Taylor, S. M. (from D to C), Manitowoc Shipbldg. Co., Manitowoc, Wis.

LOS ANGELES

Jansen, Richard M. (from D to C), Box 572, Alhambra, Calif.

NEW YORK

Oberst, Hugh J. (from D to C), 464 Van Cortlandt Part Ave., Yonkers, N. Y.
Tovey, Alfred W. (from D to C), 6 Montague Terrace, Brooklyn, N. Y.

NORTHERN NEW JERSEY

Adams, Wadsworth (from D to C), Box 87, R.F.D., Rainbow Lakes, Boonton, N. J.
Pursell, Robt. T. (from C to B), 11 Park Place, Bloomfield, N. J.

OMAHA

Begley, Paul J. (from D to C), 4109 S. 27th St., Omaha, Neb.

PHILADELPHIA

Gillespie, Forrest W. (from D to C), R.F.D. 1, Sussex Ave., Westville, N. J.

PITTSBURGH

Lawton, Frank (from D to C), Chester, W. Va.

ROCHESTER

Evarts, Stanley T. (from D to C), 257 E. Third St., Corning, N. Y.
Kadlecik, Paul (from D to C), Despatch Shops, East Rochester, N. Y.

SAN FRANCISCO

Blair, Vaughn B. (from D to C), 1917 Chestnut St., Alameda, Calif.

SOUTH TEXAS

Buenger, O. C., Jr. (from D to C), 7138 Palmetto St., Houston, Tex.

YOUNGSTOWN

Burkett, George A. (from D to C), 2423 Wilcox Ave., Youngstown, Ohio.

NOT IN SECTION

Rhinehart, Rupert F. (from D to C), 1026 W. 10th St., Erie, Pa.

1942 YEARBOOK CORRECTIONS

Omissions:

"Sustaining Company"—Williams & Company, Inc., Pittsburgh, Cleveland, Cincinnati, Columbus.
additions to members enrolled under this Sustaining Company—H. E. Williams (B), President; J. K. Nutter (C).
"Member"—R. P. Tarbell (B), Scott-Tarbell Company, 2261 E. 14th St., Cleveland, Ohio.

Correction in Address:

H. S. Card—Res. 3585 Latimore Rd., Shaker Heights, Ohio.
Thornton L. Urquhart—19151 Carman, Detroit, Mich.
Glenn Urquhart—18207 Westover, Redford Station, R. F. D. 1, Detroit, Mich.
Frank A. Jones, 60 Wall Street, Bristol, *Tennessee.*

Correction in Position:

K. L. Walker—"Assistant Superintendent," Boiler Shop, Foster Wheeler Corp., Carteret, N. J. (not Supt.).
J. A. Brown—"Welder Foreman, Second Shift" (not Asst. to Welding Foreman), Tampa Shipbuilding Company.
Harry Le Noir—"Welder Foreman, First Shift" (not Welding Superintendent), Tampa Shipbuilding Company.

Correction in Name:

James W. Ramsey—*not John* W. Ramsey.

AUSTIN CO. VICE-PRESIDENTS

W. G. Paton, of Cleveland, and W. R. Engstrom, of Seattle, have been made vice-presidents of The Austin Company, it was announced by George A. Bryant, president and general manager.

Mr. Paton, a native of Glasgow, Scotland, and educated in Civil Engineering at the Royal Technical College of Scotland, joined the Austin organization in 1919, as a structural engineer.

In January 1938, he became assistant to the general manager, and has served in that capacity since. In additon to his election as a vice-president, Mr. Paton also will assume the posts of assistant secretary and assistant treasurer of The Austin Company.

He is a member of the American Society of Civil Engineers, the AMERICAN WELDING SOCIETY, the Ohio Society of Professional Engineers and the National Society of Professional Engineers.

Mr. Engstrom was born in Perrebonne, Minnesota, and is a graduate in Civil Engineering of the University of Washington. A private in the United States Army in World War I, Mr. Engstrom joined the Austin organization as a field engineer in 1925 in the Seattle territory He became assistant to the Austin district manager in Seattle, in 1929, and district manager in 1933.

In mid-1940, Mr. Engstrom was given the additional responsibilities of general project manager of the U. S. Naval Air Station and Naval Supply Depot, Seattle, and related navy construction work in the Pacific Northwest where the Austin Company, since the outbreak of the war in Europe, has undertaken the design and construction of more than $100,000,000 worth of war facilities of all types.

Mr. Engstrom is a member of Tau Beta Pi, national honorary engineering society. He is also a member of the Rainier Club of Seattle and of the Seattle Chamber of Commerce. He is a member of the American Society of Civil Engineers and a past president of the Seattle Section of the Society.